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(54) **Interactive control system for packaging control**

Interaktives Steuerungssystem für eine Verpackungssteuerung

Système de commande interactive pour une commande d'emballage

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(73) Proprietor: **JOHNSON & JOHNSON VISION
PRODUCTS, INC.
Jacksonville, Florida 32216 (US)**

(72) Inventors:
• **Lepper, John Mark
Jacksonville, Florida 32257 (US)**

• **Edwards, Russell James
Jacksonville, Florida 32258 (US)**
• **Wang, Daniel Tsu-Fang
Jacksonville, Florida 32225 (US)**

(74) Representative: **Mercer, Christopher Paul et al
Carpmaels & Ransford
43, Bloomsbury Square
London WC1A 2RA (GB)**

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Description

1. Field of the Invention.

5 **[0001]** This invention relates generally to a contact lens manufacturing facility for producing ophthalmic contact lenses, and, in particular to a control system for consolidating the serial flow of lens packages for packaging thereof.

2. Description of the Prior Art.

10 **[0002]** The direct molding of hydrogel contact lenses is disclosed in U.S. Patent 4,495,313 to Larsen, U.S. Patent 4,680,336 to Larsen et al., U.S. Patent 4,565,348 to Larsen, and U.S. Patent 4,640,489 to Larsen et al. Essentially, these references disclose an automated contact lens production process wherein each lens is formed by sandwiching a monomer in a mold cavity formed between back curve (upper) and front curve (lower) mold halves. The monomer is polymerized, thus forming a lens, which is then removed from the mold cavity and subject to further processing such 15 as hydration, automatic lens inspection (ALI), and packaging for consumer use.

[0003] Prior art processes significantly reduce the thruput time by hydrating the lens and releasing the lens from the mold cavity with ionized water and a small amount of surfactant without any salts, so that the time consuming ionic neutralization of the polymer from which the lens blank is made does not occur during the hydration process. When deionized water is used, the final step of the process is to introduce buffered saline solution into the final package with 20 the lens and then seal the lens within the package so that the final lens equilibrium (ionic neutralization, final hydration and final lens dimensioning) is accomplished in the package at room temperature or during sterilization.

[0004] In view of the foregoing, it is necessary to remove the deionized water from the packages to enable the package to be filled with buffered saline solution. However, the final product is defective if the lenses remain dry for an extended period of time and if they experience high-speed movement causing dislocation of the lenses. Thus, the 25 time that the de-ionized water is removed from the packages to the time that the packages are filled with a saline solution at a subsequent packaging station, must not exceed a predetermined time limit.

[0005] Therefore, it would be highly desirable to incorporate in a lens packaging station, a control means for tracking the elapsed time that individual lens packages or arrays of lens packages are maintained in a dry state after deionized water removal.

30 **[0006]** It would also be highly desirable to incorporate in a lens packaging station, a control means for tracking the position of each lens package or arrays of lens packages from a deionized water removal station to a lens packaging station in addition to tracking the elapsed dry-time status of each the lens package array.

[0007] US 4,888,692 discloses a real time scheduling system, wherein there is a controller for determining elapsed time data for each individual machine within the system, performing a process flow. A global definition is made once 35 and each machine has an individual profile describing its local interaction with the system. This disclosure details a method by which successive process steps may be carried out with very little wait between them. The timing of this set of steps is controlled by the slowest process step therein. A separate data structure is kept for each such set, the structure indicating amongst other things the beginning and end processes, listing the processes by number and giving the total processing time of the set.

40 **[0008]** US 4,805,778 discloses a method and apparatus for the manipulation of products, comprising a controller for generating position status data indicating a good or bad array of defective products. The position of a defective product is first established in a defective product detection zone, that position being fed to a controller which then tracks the defective product as it moves along a conveyor. A defective product removal means is then utilised to remove the product when it is within range, said device utilising the tracked position to locate the defective product. The defective 45 product is then moved to a location for receiving such products.

[0009] EP 0501382 discloses a machine for grouping in rows products arriving in a single line. The machine includes an actuation chain which is closed in a loop and is provided with a plurality of seats which perform a corresponding closed path, moving from a side for loading individual products to a side for unloading rows of products. A swinging conveyor is arranged at the loading side, which moves in a stepwise manner thereby aligning with the individual seats 50 enabling the deposit therein of products and EP 0558035 discloses a device for unstacking dishes from a washing machine comprising two adjoining conveyors moving in linear succession to move dishes from the washing machine, and an intermediate storage station which collects dishes for common further transport therefrom.

SUMMARY OF THE INVENTION

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[0010] In view of the foregoing, there is provided an interactive control system constructed and arranged for controlling the automatic packaging of products in a product fabrication facility, as claimed in claim 1 hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The foregoing objects and advantages of the present invention for a contact lens production line pallet system may be more readily understood by one skilled in the art with reference being had to the following detailed description of several preferred embodiments thereof, taken in conjunction with the accompanying drawings wherein like elements are designated by identical reference numerals throughout the several views, and in which:

Figure 1 is a simplified diagrammatic illustration of a contact lens package consolidation system incorporating the interactive packaging control system of the instant invention;

Figure 2 is an isometric view of a contact lens carrier which serves as both an inspection carrier, and a portion of the final contact lens package.

Figure 3 is an isometric view of an inspection carrier used to transport a plurality of the contact lens carriers illustrated in Figure 2 through the automated lens inspection station.

Figure 4 is an elevation view of the automated lens inspection system and the stations utilized in the initial handling of the lenses prior to lens package consolidation.

Figure 5 illustrates in detail an individual robotic handling device transporting contact lens carriers to the consolidation vacuum rail of the present invention

Figure 6 illustrates the PLC flow diagram for accomplishing DI-water removal at the deionized water removal station.

Figures 7(a), (b) and (c) illustrate the detailed PLC flow diagram for transferring packages from the DI-water removal conveyor to the vacuum rail stack, and for balancing the placement of good lens packages on the stack.

Figures 8(a) and 8(b) illustrate the detailed PLC flow diagram for calculating the total number of packages to be transferred from one rail of the stack to the other rail for accomplishing balancing.

Figures 8(c) and 8(d) illustrate respective detailed PLC flow diagrams for determining which specific packages held by the robot gripper are to be transferred from vacuum rail A to B or vacuum rail B to A, respectively, for balancing.

Figure 9 illustrates the detailed PLC flow diagram for controlling package lens consolidation on the vacuum rail stack of the packaging station.

Figures 10(a) - 10(f) illustrate the detailed PLC logic flow diagram for transferring packages containing contact lens to either the indexing rotary package dial, or, the consolidation buffer area.

Figure 11 illustrates a plan view of the rotary indexing package dial 200 and the stations thereat for processing the contact lens packages after consolidation.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0012] Referring to Figure 1, there is shown a simplified diagrammatic view of the packaging system 10 implemented in a contact lens fabrication facility having an automatic lens inspection system and automated lens package consolidation system. and, in further view of Figure 4, arrays of soft contact lenses are transferred from a hydration station (not shown), after being subject to a hydration process, and placed in individual package bottoms (packages) loaded in an inspection pallet by a robotic apparatus 22 for conveyance through a post hydration automatic lens inspection (ALI) station 20, and, a DI water removal station 25 of the contact lens fabrication facility. The loaded pallet is first moved by a conveyor (not shown) to a deionized water injection station 16 wherein each of the packages transported on the inspection pallet are partially filled with degassed and deionized water. The inspection pallet is then transferred by a push conveyor to an overhead double index conveyor and then handled by a side grip conveyor as it conveyed through the ALI station. After deionized water removal and robotic device pick-up, the inspection pallet is subsequently returned to receive a new set of packages where the process is repeated.

[0013] Figure 2 illustrates the preferred embodiment of the lens package base 15 for carrying a contact lens, and, Figure 3 illustrates the preferred embodiment of a lens inspection pallet 16 for carrying a predetermined number of the contact lens packages, one of which is shown in the pallet, throughout the automatic lens inspection (ALI) station and lens package consolidation station 10. The structural details of both lens package 15 and lens package pallet 16 are described in detail in the above-mentioned co-pending case VTN-81.

[0014] As can be seen in Figure 3, the lens package pallet 16 is capable of carrying up to sixteen (16) packages in a 2 X 8 array.

[0015] As shown generally in Figure 1, the packaging control system 11 includes a control device 100 which may be a computer or one or more programmable logic controllers (PLC) and a corresponding memory device 102 for controlling the serial conveyance and robotic handling of packages from an automatic inspection station 20 to a packaging dial 200 where secondary packaging of the contact lens package is commenced. More specifically, the packaging control system functions to keep track of good lens/defective lens status information as determined at the ALI station

20; to control the deionized water removal for each lens package prior to conveyance to a packaging dial; to control robotic handling and transfer of lens packages from the deionized (DI) water removal station 25 to a consolidation vacuum rail or stack 50, including enabling rejection of specific lens packages containing defective lenses as determined at the ALI station; to consolidate the serial flow of lens packages on the stack 50 when particular packages have been rejected as containing defective lenses; to keep track of the time elapsed from deionized water removal to placement at a delivery location 202 on the packaging dial 202 for each lens package array; to control robotic handling of package arrays containing ten packages in a 2 X 5 array from the vacuum rail to a support pallet 201 indexed by the rotary indexing packaging dial 200 to ensure serial flow thereto; to control the storage and retrieval of lens package arrays from support pallets 201 located at a lens package buffer storage area 180 if a lens package array can not be placed on the support pallet at the indexing package dial, or, if the vacuum rail cannot supply packages to the dial when requested; and, to control specific lens packaging processes at a variety of process stations located about the rotary indexing package dial that include: a verification station 204 for verifying the presence and alignment of each package array base in the support pallet; a saline dosing station 206 that is provided with an array of dosers for depositing a given dosage of saline solution in each package; a saline level checking station 208; a final product check station to a foil receiving station 210, where a sheet of laminated covers is picked and placed over the array of package bases; a heat sealing station 212 wherein a heated seal head heat seals the laminated covers to each package base; and, an unloading radial station 214 where an unloader arm unloads the sealed packages from the rotary indexing package dial for subsequent processing.

[0016]   In the preferred embodiment shown in Figure 1, control means 100 constitutes a single PLC, and associated circuitry and software, for providing the tracking and serial flow of products. Preferably, the PLC is a TI system 545 (Texas Instruments). The PLC is programmed with Application Productivity Tool (APT) software. As shown in Figure 1, a memory storage device 102 having adequate addressing and storage capabilities for the PLC 100 to access and process data in the form of elapsed dry-time information and positional status information, is provided. Specifically, the elapsed dry-time information indicates the time elapsed from deionized water removal of a particular lens package at the DI water removal station, to its placement on the packaging dial. If the elapsed time for any particular package is determined to be over a specific limit, then the lens package array containing that timed out lens package will subsequently be rejected by the second buffer robot. Elapsed dry-time information for each lens package array described hereinafter, is contained in the variable POS_ARR[i], where index i = 1,..,50, 60, 61, and 101 i.e., and STACK_ARR [j], where index j = 1,2..,10 the major locations designated in this portion of the packaging system. In the preferred embodiment, elapsed dry-time data is shifted within these variables (16-bit registers) in memory 102 as each lens package array is conveyed to the different positions.

[0017]   The positional status information for each lens package array represents the good/bad status of that package array throughout locations of the package consolidation station of the lens packaging station, and, particularly, the locations on the serial vacuum rail and buffer storage area. Positional status information for each lens package array described hereinafter, is represented as the variable POS_OCC[i], where the index i = 1,..,50, i.e., and STACK_ARR [j], where the index j = 1,2,..,10, the major locations that a particular lens package array occupies. The values stored in this array may either be a "0", indicating that the particular location is not occupied by a lens package, a "1", indicating that the lens package at that array is good, or, a "2" indicating that the package array at that particular location contains a defective lens package due to elapsed dry time. As shown in Figure 1, the indexes for the STACK_ARR[i] and STACK_OCC[i] arrays are indicated in brackets { } wherein: the position indicated as {10} represents the DI water removal location where time stamping is initiated; position {9} represents the package array pick-up point at the DI water removal conveyor 26 location; position {8} represents the good/bad robot tooling (gripper) location when the robot gripper 45 holds an array of packages; position {7} represents the package delivery point at the vacuum rail 50; positions {6} - {1} represent the locations on the vacuum rail 50 (stack) as lens packages are forwardly advanced and accumulate thereon for buffer robot pickup at transfer point 57; the positions represented by POS_ARR[i] and POS_OCC[i] arrays are the positions located in the buffer area and the rotary package dial 200. For instance, the position indicated as {50} in Figure 1, represents the buffer robot tooling (gripper) location when the robot gripper 65 holds an array of packages for transfer. Other variables used in the packaging control system will become evident as discussed below.

DI Water Removal Station

[0018]   As shown in Figure 1, the contact lenses contained in their package bottoms in a deionized water solution are transported from the ALI station 20 in the direction of arrow "A" to a deionized water removal station 25 where the deionized water must be removed from the package to enable subsequent filling with buffered saline solution. Specifically, the DI water is removed to enable each package array to be swiftly transferred from serial flow out of the ALI station 20 to the vacuum rail 50, and, from the vacuum rail 50 to the buffer storage area 180, or, support pallet 201 on package dial 200. However, a contact lens will be considered defective if it remains dry for 14 minutes or longer. Thus,

it is necessary that after DI water removal occurs, the PLC 100 initiate a time stamp to enable elapsed dry-time tracking in PLC memory.

[0019]   As shown in Figure 4 and the process flow chart of Figure 6, DI-water removal is accomplished by a pressurized air cylinder 28 having individual nozzles (not shown) that are registered above each 2 X 8 pallet containing the array of lens packages. The nozzles are specially configured nozzles, such as described in EP-A-0 618 063.

[0020]   After the air blow pressure check, indicated at step 71 in Figure 6, the air blow cylinder is extended to a lower registered position, indicated at step 73, and the air blow is initiated at step 75. It is understood that the force and duration of the air blow upon the individual lens packages of the array is carefully controlled so as to not disrupt or remove the contact lens contained therein. Furthermore, the construction of the nozzle is such that a vacuum venturi effect is created so that the force of the compressed air enables the DI-water to evacuate the package without harming the lens. After the air blow is terminated at step 77, the air blow cylinder 28 is retracted to its upper position (not shown) as indicated at step 79. The final step indicated at step 81 is to initiate the elapsed time stamp information. As shown in Figure 6 the following variables are initialized:

STACK_OCC[10]:=1;
STACK_ARR[10]:=1;

[0021]   The value of "1" assigned to STACK_OCC[10] indicates that the position {10}, i.e., DI-water removal position is occupied with a pallet containing a package array of good lenses. The value of "1" assigned to STACK_ARR[10] indicates that the time stamp has been initiated. It should be understood that control means 100, as implemented by the PLC, includes a continuously running master clock (not shown) for real time tracking. The current time stamp information is stored as a variable TODS (time of day stamp). As a new time stamp is generated, the old TODS value is assigned to the variable OLD_TODS. The elapsed time, stored as variable ELAP_SEC is calculated as follows:
BEGIN
ELAP_SEC :=ROUND(TODS-OLD_TODS);
OLD_TODS :=TODS;
END

[0022]   This is a free-running math text that is run continuously so that elapsed time and positional values will always be updated. The maximum dry time exposure that is acceptable is stored in the variable DRY_TIME and is about 14 minutes.

Transfer of Package Array to Robot Pick-Up Point

[0023]   After deionized water removal from the lens packages, the package array is conveyed along DI-water removal conveyor 26 to the first Robot pick-up point where the individual packages 15 containing contact lenses are to be removed from the pallet 16 by a good/bad robot 40 (Robot 1) having a robot gripper 45 with independently actuable vacuum grippers which engage the packages at the pick-up point. The pallet 16 containing the 2 X 8 array of lens packages is conveyed to the robot 40 pick up point 29 as indicated in Figure 1, and the positional status and elapsed dry time status information is transferred to the positional status array for the Robot 1 pick-up point indicated as position {9} in Figure 1. Thus, the information from the previous position (DI-water removal position {10}) stored in STACK_OCC [10] and the elapsed dry-time since DI-water removal stored in STACK_ARR[10] is assigned to the respective variables representing the new position STACK_OCC[9], STACK_ARR[9], respectively. Specifically,

STACK_OCC[9]:=STACK_ARR[10];
STACK_ARR[9]:=STACK_ARR[10];

[0024]   The elapsed time and positional information for the DI-water removal position {10} is re-initialized for the new process to occur at that position. Thus, STACK_OCC[10]:=0, indicates that there is an unoccupied position at location {10}. Additionally, STACK_ARR[10]:=0, indicates that there is no time stamp information at the position {10}. The elapsed time that is transferred between the STACK_ARR[i] registers as the package arrays are transported through the system is calculated as above.

Transfer of Package Array from Robot to Vacuum Rail

[0025]   Once the pallet carrying the 2 X 8 array of lens packages is at the robot pickup position, the PLC commands the robot to pick up all 16 individual lens packages from the array.

[0026]   As described above and in greater detail in the above-mentioned co-pending case VTN-81, the vacuum gripper 45 of robot apparatus 40 comprises two side rows 46(a) and 46(b), of eight (8) individuated vacuum gripper nozzles

each, that are enabled to pick up to sixteen lens packages at a time (in a 2 X 8 array) from the package pallet 16 and place up to eight (8) lens packages onto each respective vacuum rail A and B of vacuum rail 50, the cross-section of which is illustrated in Figure 5. As described in greater detail below, if any or some of the lenses are defective as determined at the ALI vision inspection system, then the PLC will command the Robot 40 to reject those specific packages 15(a),(b) containing defective lenses, and place them onto reject conveyor 41 as shown in Figure 1. Immediately thereafter, the robot 40 transfers the remaining lens packages on the vacuum rail stack 50, for conveyance to the packaging dial 200. Thus, in each cycle, there may be random empty locations on each vacuum rail A and B where a package would have been placed. The vacuum rails A and B thus, need to be consolidated and the empty locations filled in each cycle to enable the vacuum gripper 65 of buffer robot 60 to pick ten (10) lens packages in a 2 X 5 array from vacuum rail 50 and deposit them in a support pallet 201 located at a predetermined position 202 on a the package dial 200, or, in one of a plurality of buffer pallets 201 located at the lens package buffer area 180 as shown in Figure 1 and 11. As explained below, it is desired to maintain the difference between the amount of lens packages placed on rails A and B of vacuum rail 50 to be within one (1) package.

Vacuum Rail Balancing and Consolidation

[0027] As shown in Figure 7(a), an initialization step 111 initializes all software variables and math subroutines and disables all software interlocks for the PLC control. After a start signal is received at step 113, the PLC determines at step 115 whether any of the lenses at the robot pick-up point 29 are too old, i.e., if the current elapsed time STACK_ARR [9] is less (<) than the dry time-out limit DRY_TIME. If not, then the robot gripper 45 will pick up the lenses at the predetermined array pick-up point 29. Thus, at step 117, the coordinates of the pick-up position 29 at the DI_water removal conveyor 26 are communicated to the Robot 40 by the PLC. After receiving the robot handshake at step 119, the robot is commanded to move to the pick-up position at step 121. When the robot reaches the position at step 123, a vacuum is applied to nozzle side 46(b) (side B) of the robot gripper so that up to eight lenses may be picked up from the pallet, as shown at step 125 in Figure 7(a). In the preferred embodiment, eight (8) packages are picked up at a time by the robot 40 for each nozzle side. At step 127, a vacuum is applied to nozzle side 46(a) of the robot gripper so that up to eight lenses may be picked up from the other row of packages from the package pallet. After all sixteen packages are picked up, and, as shown in Figure 7(a) at step 129, the information from the previous position (package pick-up position {9}) stored in STACK_OCC[9] and the elapsed dry-time since DI-water removal stored in STACK_ARR [9] is shifted to the respective variables representing their new position held by the robot gripper, i.e., STACK_OCC [8], STACK_ARR[8], respectively. Specifically,

$$STACK\_OCC[8]:=STACK\_ARR[9];$$
$$STACK\_ARR[8]:=STACK\_ARR[9];$$

The elapsed time and positional information from the package pickup position {9} is re-initialized for the new process to occur at that position. Thus, STACK_OCC[9]:=0, indicates that there is an unoccupied position at location {9}. Additionally, STACK_ARR[9]:=0, indicates that there is no time stamp information at the location {9}.

[0028] After the robot move to pick-up the array, the previously determined pass/fail shift register data for the respective lenses in the package array is indexed for evaluation by the PLC which will make the determination as to whether any particular package is defective. This information is evaluated by the PLC and communicated to the robot if any lenses need to be rejected. The variables RO_STAT_A and RO_STAT_B are the variables for respective robot gripper sides 46(a) and 46(b) having values from 0 to 255 that indicate which specific lens or lenses are defective. The 16 bit register storing that variable will have a logic 0 in a specific bit location corresponding to a specific numbered location, i.e., 1 to 8 (gripper side A) and 9 through 16 (gripper side B) as illustrated in Figure 1 to indicate that the lens carried by that specific gripper nozzle should be rejected. Thus a value equal to 255 indicates that all lenses are good. Any value less than that indicates that there exists a defective lens.

[0029] As shown in Figure 7(b), the next function is to move the robot to the position above the idler conveyor 41 where lenses may be dropped if they are determined to be defective. Thus, at step 131, the coordinates of the idler conveyor position 41 are communicated to the Robot 1 by the PLC. After receiving the robot handshake at step 133, the robot is commanded to move to the package reject position at step 135. When the robot reaches the position at step 137, the PLC will determine if any of the lenses are defective at step 139, and, as indicated by the logic at step 139a. Thus, the logic:

$$RO\_STAT\_A < 255$$
$$RO\_STAT\_B < 255$$

is evaluated. If each relation is true, the robot will dump the individual defective lens packages from the respective

nozzle gripper sides on to the idler conveyor 41 as indicated at step 142. If all the lenses for the particular array have failed ALI inspection, i.e., RO_STAT_A = 0 and RO_STAT_B = 0, as indicated at step 142a, then robot will return to its home position (step 11 of Figure 7(a)) as indicated at step 143, and wait for a request to pick up a new package array at the package pick-up point; otherwise, there are still good lenses to be transferred to the vacuum rail 50. Specifically, the PLC first waits for a vacuum rail ready signal as indicated at step 145, and after it is received, the PLC communicates the coordinates of the vacuum rail stack delivery position, position {7}, as indicated at step 147 in Figure 1, to the robot 40. After receiving the robot handshake at step 149, the robot is commanded to transfer the remaining good lens packages to the stack position at step 151. When the robot reaches the stack delivery position as indicated in Figure 7(c) at step 153, the PLC will determine, at step 155, the difference between the number of lens packages that remain gripped by robot gripper side A and gripper side B to effect balancing of the placement of the packages onto the vacuum rail stack side A,B respectively, to within one package. Figures 8(a) and 8(b) illustrate the PLC programmed logic flow for balancing the vacuum rail stack 50.

[0030]   The variable arrays VAC_ARR _A[i] and VAC_ARR _B[j], i = 1,..,8, andj = 1,..,8, are programmed to hold the RO_STAT_A and RO_STAT_B vacuum status information, respectively, of the robot vacuum gripper nozzles to determine the remaining good packages to be transferred from the robot gripper 45 of first robot assembly 40 to respective vacuum rail lines A and B. Specifically, each of the eight (8) locations of each array are tested to determine if the packages (i.e., lenses) carried by the robot gripper for each vacuum rail A,B are present, i.e., have not already been determined to be defective and selectively rejected by robot assembly 40 and disposed of at the reject conveyor 41. If the vacuum status for the specific position of a package held by the robot is activated, then the package will be placed on the corresponding rail array. A running total is kept for each package to be transferred to each vacuum rail A,B. From each total, it is thereafter readily determined how many packages need to be moved and to which side rail so as to maintain the vacuum rail A,B balance to within one (1) package.

[0031]   As shown at step 202 in Figure 8(a), the total count of good packages present for transfer to each vacuum rail is initialized at zero for each rail A,B. Specifically, the variable NUMB_A and NUMB_B are set equal to zero and the indexes i,j are each set equal to 1. The next series of steps checks the vacuum status information for each package held by the robot gripper to determine which packages the robot will transfer to each vacuum rail. Thus, at step 204, the vacuum status VAC_ARR _A[i] for each of the robot pick/place positions for rail A is checked for each iteration of index i. For each good package present, a tally of the total number of good packages NUMB_A to be transferred to each side rail A is calculated at step 206 for each iteration. At step 208, the vacuum status VAC_ARR _B[j] for each of the robot pick/place positions for rail B is checked for each iteration of index j. For each good package present, a tally of the total number of good packages NUMB_B to be transferred to each side rail B is calculated at step 211 for each iteration. A check is made at step 213 to determine if the vacuum status at all eight (8) positions for each vacuum rail A,B has been checked. If not, the indexes i and j are incremented at step 215 and the cycle is repeated for the next package positions of arrays VAC_ARR _A[i] and VAC_ARR _B[j] until all sixteen positions have been checked.

[0032]   In the next step 217, a determination is made as to the total amount of lens packages to be transferred in the current cycle. This is a simple addition of the total number of transferable packages, NUMB_A + NUMB_B, and this value will subsequently be used as explained in greater detail below. Steps 219 and 221 of Figure 8(a) comprise the logic to compare the values of NUMB_A and NUMB_B, respectively, and determine the difference DIFF_A, DIFF_B, respectively, between the total number of packages to be transferred on each respective side rail A,B. If NUMB_A > NUMB_B, then there are more packages to be transferred to rail A, and one or more of these packages, determined by the variable DIFF_A, will have to be transferred to vacuum rail B for balancing. Similarly, as shown in steps 223 and 226, if NUMB_B > NUMB_A, then there are more packages to be transferred to rail B, and one or more of these packages, determined by the variable DIFF_B, will have to be additionally transferred to vacuum rail A for balancing. If NUMB_B = NUMB_A, then an equal number of packages are to be transferred to each side rail, and balancing need not be performed as indicated at step 228.

[0033]   Steps 229 through 239 include the logic for determining exactly the number of packages that are to be transferred from rail A to rail B, represented by the variable MOVE_A, or, from rail B to rail A, represented by the variable MOVE_B. Thus, if DIFF_A > DIFF_B as shown at step 229, and the value of DIFF_A >= 2, as shown at step 231, then variable MOVE_A is calculated at step 233 as the value of the variable DIFF_A divided by two (2). Otherwise, there is no further need to balance, as indicated at step 232. As discussed below, it is next determined at steps 243 et seq. of Figure 8(c) exactly which specific package will be transferred from vacuum rail A to a corresponding position on vacuum rail B. Therefore, if DIFF_B > DIFF_A as shown at step 236, and the value of DIFF_B >= 2, as shown at step 238, then variable MOVE_B is calculated at step 239 as the value of the variable DIFF_B divided by two (2). Otherwise, there is no further need to balance, as indicated at step 241. A subsequent determination is made at steps 253, et seq. of Figure 8(d), which specific package will be transferred from vacuum rail B to a corresponding position on vacuum rail A, as discussed below.

[0034]   Once the determination is made as to the amount of packages that need to be transferred and to which vacuum rail A or B requires the packages, (stored in the variable MOVE_A or MOVE_B), a determination is made at

step 157 in Figure 7(c) as to which specific package is to be moved by the robot gripper 45 from one vacuum rail to the other. This is based upon which package positions are empty on the side requiring the additional packages. Steps 243 to 249 in Figure 8(c) illustrate the sequence for determining which locations are free on vacuum rail B so that lens packages can be transferred from vacuum rail A. Array MOV_ARR_A[i], where i = 1,..,8, is the array that is defined to indicate which actual package(s) held by the robot gripper 45 will be moved. Alternately, steps 253 to 259 in Figure 8 (d) illustrate the sequence for determining which locations are empty (free) on vacuum rail A so that lens packages can be transferred from vacuum rail B. Array MOV_ARR_B[j], where j = 1,..,8, is the array that is defined to indicate which actual package(s) held by the robot 45 gripper will be moved. It is understood that the robot 40 does not physically remove packages from line A to line B, but retains those packages by individual vacuum nozzle grip at positions corresponding to locations where those packages would be placed on line vacuum rail A, so that they may be subsequently transferred instead to determined free positions on rail B in a subsequent movement. Likewise, the robot 40 does not physically remove packages from line B to line A, but retains those packages by vacuum nozzle grip at positions corresponding to locations where those packages would be placed on line vacuum rail B, so that they may be subsequently transferred instead to determined free positions on rail A in a subsequent movement.

[0035] As shown at step 243 in Figure 8(c), the pointer FRE_FOU_A, which indicates the number of empty (free) locations in vac. rail line B, is initialized as equal to zero (0). Additionally, indexes i and j are set equal to one (1). Array VAC_ARR _A[i] i = 1,..,8, represent the good package locations, i.e., those locations where the packages carried by the robot gripper in vacuum nozzle gripper row A can be placed onto corresponding vacuum rail A. Each position in array VAC_ARR _B[j], where j = 1,..,8, represent the previously determined filled (not free) package locations.

[0036] The following steps 243 through 249 in Figure 8(c) illustrate the logic for determining which selected packages will be placed from vacuum rail A, to vacuum rail B to fill the empty positions and maintain the balance of placed lens packages to within one on each vacuum rail. Specifically, at step 245, the status of a package location on vacuum rail A indicated by array VAC_ARR _A[i] is compared to the corresponding location on vacuum rail B indicated by array VAC_ARR _B[j] to determine if a package present on rail A can be moved to a corresponding free position on rail B by the robot gripper. Another check is made at step 247 to ensure that the current value of FRE_FOU_A is less than the total number of packages that have to be moved, i.e., FRE_FOU_A < MOV_A. If the above conditions are met, then at step 248, the current value of FRE_FOU_A is incremented by one (1), and a true condition is assigned to the position MOV_ARR[1] at step 249 to indicate that particular package is to be transferred to vacuum rail B. A check is made at step 246 to determine if all eight (8) transfer positions for transfer of specific packages from rail A to rail B have been checked. If not, the indexes i and j are incremented at step 244 and the cycle is repeated for the next package positions of arrays VAC_ARR _A[i] and VAC_ARR _B[j] until all eight positions have been checked.

[0037] The PLC then determines at step 159 of Figure 7(c) as to whether lenses are to be moved from vacuum rail A to vacuum rail B. If this is the case, then at step 161 the appropriate coordinates are input to the robot 40 by the PLC. The robot is then commanded to start the package transfer at step 163.

[0038] As shown at step 253 in Figure 8(d), the pointer FRE_FOU_B, which indicates the number of empty (free) locations in vac. rail line A, is initialized as equal to zero (0). Additionally, indexes i and j are set equal to one (1). Array VAC_ARR _B[j] j = 1,..,8, represent the good package locations, i.e., those locations where the packages carried by the robot gripper in gripper row B were placed onto corresponding vacuum rail B, and that have not been selectively disposed of as containing defective lenses. Each position in array VAC_ARR _A[i], i = 1,..,8, represent the previously determined filled (not free) package locations.

[0039] The following steps 255 through 263 in Figure 8 (d) illustrate the sequence for moving selected packages, intended to be placed on vacuum rail B, to vacuum rail A to fill the empty positions and maintain the balance of placed lens packages to within one on each vacuum rail. Specifically, at step 255, the status of a package location on vacuum rail B indicated by array VAC_ARR _B[j] is compared to the corresponding location on vacuum rail A indicated by array VAC_ARR _A[i] to determine if a package present on rail B can be moved to rail A by the robot gripper. Another check is made at step 257 to ensure that the current value of FRE_FOU_B is less than the total number of packages that have to be moved, i.e., FRE_FOU_B < MOV_B. If the above conditions are met, then at step 258, the current value of FRE_FOU_B is incremented by one (1), and a true condition is assigned to the position MOV_ARR[1] at step 259 to indicate that that particular package is to be transferred to vacuum rail A. A check is made at step 261 to determine if all eight (8) transfer positions for transfer of specific packages from rail A to rail B have been checked. If not, the indexes i and j are incremented at step 263 and the cycle is repeated for the next package positions of arrays VAC_ARR _A[i] and VAC_ARR _B[j] until all eight positions have been checked. A determination is then made at step 159 of Figure 7(c) as to whether lenses are to be moved from vacuum rail B to vacuum rail A. If this is the case, then at step 162 the appropriate coordinates are input to the robot 40 from the PLC. The robot is then commanded to start the package transfer at step 163.

[0040] After the lens packages have been transferred to the empty locations on vacuum rail by robot gripper, as indicated as step 163 in Figure 7(c), the information from the previous position (robot gripper position {8}) stored in STACK_OCC[8] and the elapsed dry-time since DI-water removal stored in STACK_ARR[8] is shifted to the respective

variables representing their new position on the stack i.e., STACK_OCC[7], STACK_ARR[7], respectively. Specifically, at step 165 in Figure 7(c).

    STACK_OCC[7]:=STACK_ARR[8];
    STACK_ARR[7]:=STACK_ARR[8];

The elapsed time and positional information from robot tooling position {8} is re-initialized for the new process to occur at that position. Thus, STACK_OCC[8]:=0, indicates that there is an unoccupied position at location {8}. Additionally, STACK_ARR[8]:=0, indicates that there is no time stamp information at the location {8}.

[0041]   If the current elapsed time STACK_ARR[9] is greater (>) than the dry time-out limit DRY_TIME, as determined at step 115 in Figure 7(a), then the robot gripper 45 will pick up the lenses at the predetermined pick-up position 29 and reject all of the lenses immediately on to the reject (idler) conveyor 41. Thus, at step 167, the coordinates of the pick-up position 29 at the DI_water conveyor 26 are stored within Robot 40 and request pick-up position 29 is communicated to the Robot 40 by the PLC. After receiving the robot handshake at step 169, the robot is commanded to move to the pick-up position. When the robot reaches the position, a vacuum is applied to side B of the robot gripper nozzles so that they may pick-up packages from the first row of the pallet array, as shown at step 171 in Figure 7(a). Since, sixteen (16) packages in a 2x8 array are picked up at a time by the robot 40, a vacuum is then applied to side A of the robot gripper nozzles so that lenses may be picked up from the other row of packages from the package pallet. This is indicated at step 173. Since these packages have been determined to be old, the next step 176 is to communicate to the robot 40 the coordinates for movement to the reject position. After receiving the robot handshake at step 177, the robot is commanded to move to the package reject position at step 178. When the robot reaches the position at step 179, the PLC will command the robot to dump the packages as indicated at step 181. Finally, the robot is commanded to move to a home position at step 183, and is returned to step 111 to begin the pick-up and place sequence for the next cycle.

Vacuum Rail Consolidation

[0042]   After lens packages are balanced on respective sides A,B of the vacuum rail stack 50, consolidation takes place. A pair of independently advanceable pneumatic stacking cylinders 52(a), 52(b), shown interfaced with the PLC in Figure 1, are extended in the direction of arrow "B" to advance the placed packages from their present positions on respective vacuum rails A,B (stack) and consolidate them at the buffer robot 40 (pick-up) point 57 located at the end of the stack. Besides ensuring efficient automatic serial product flow, consolidation is necessary to ensure that the robot gripper 65 of the second robot (buffer) assembly 60 will pick up a 2 X 5 array of lens packages at each machine cycle, or, perform a different function depending upon the respective status of the stack, the buffer storage area, and, the indexing package dial. Operational details of the cylinders 52(a),52(b) are described in further detail in the above-mentioned co-pending case VTN-81.

[0043]   Figure 9 illustrates the PLC logic employed for controlling the vacuum rail consolidation aspect of the packaging station, and, further, the logic for shifting elapsed dry time status information and positional information for each lens package array as it is advanced along the vacuum rail. The first step 301, is to initialize all - subroutines including the routine for determining the next free position on the stack, i.e., positions {7} through {1} as shown in Figure 1, and the routine for moving the time and positional data to the next free position. Thus, at step 305, a decision is made as to whether the first position 57 on stack 50 is empty or free which would indicate that robot 60 has just picked a 2 X 5 array from the stack and the stack is full. Each and every position on the stack will be considered free because the stacking cylinders will advance each lens package array on the stack to the next free position on the stack. Thus, if position {1} is unoccupied and there is no elapsed dry time status information for position {1}, i.e.,

if STACK_OCC[1]=0; then then each elapsed dry time status and positional status data for each location on the stack is shifted to the next free location, as indicated at step 307, i.e.,

```
STACK_ARR[1]:=STACK_ARR[2];
STACK_OCC[1]:=STACK_OCC[2];
STACK_ARR[2]:=STACK_ARR[3];
STACK_OCC[2]:=STACK_OCC[3];
STACK_ARR[3]:=STACK_ARR[4];
STACK_OCC[3]:=STACK_OCC[4];
STACK_ARR[4]:=STACK_ARR[5];
STACK_OCC[4]:=STACK_OCC[5];
STACK_ARR[5]:=STACK_ARR[6];
STACK_OCC[5]:=STACK_OCC[6];
STACK_ARR[6]:=STACK_ARR[7];
STACK_OCC[6]:=STACK_OCC[7];
```

[0044]   Concurrently, at step 303, the package positioning cylinder 54, which is extensible in the directions indicated by arrow "C" as shown in Figure 1 to align package arrays at a fixed reference location so that the robot 60 may pick up the package array, is retracted from its extended position. Then, at step 309, the stacking cylinders 52(a),(b) are commanded to extend forward in the direction of arrow B in Figure 1 along the rail until the string of lens packages or the stacking cylinders themselves trigger either of the limit sensors 56(a),(b) at step 310. Until the packages or a stacking cylinder triggers the limit sensors 56(a),(b), the system is in a wait mode as indicated at step 311. After the limit sensor is triggered, the PLC enables the stacking cylinders to retract to their original positions beyond the package delivery point (position {7} shown in Figure 1) as shown at step 312 in Figure 9(a). Next, the packaging position cylinder is extended in the direction of arrow "C" in Figure 1 and indicated at step 314 to align the lens packages present at the fixed reference position {1} so that the second robot 60 may pick up the array from that position.

[0045]   After the positioning cylinder is extended, the elapsed dry-time and positional status information from the package array positions on the stack must be advanced in accordance with their new locations on the stack. For e.g., the packages that were present on the stack at position {7} (package placement position) may be advanced by the stacking cylinders to position {1}, or {3}, or {6}, for e.g., depending upon the amount of packages already placed on the stack. Thus, the next step 316 is to shift the elapsed time and status data accordingly to that stack position. To find that position and shift the data, the following logic is employed:

```
IF LENS_IN_STAC > 0 AND LENS_IN_STAC < 10 THEN
     NEXT_STAC:=1;
ENDIF;

IF LENS_IN_STAC > 10 AND LENS_IN_STAC < 20 THEN
     NEXT_STAC:=2;
ENDIF;

IF LENS_IN_STAC > 20 AND LENS_IN_STAC < 30 THEN
     NEXT_STAC:=3;
ENDIF;

IF LENS_IN_STAC > 30 AND LENS_IN_STAC < 40 THEN
     NEXT_STAC:=4;
ENDIF;

IF LENS_IN_STAC > 40 AND LENS_IN_STAC < 50 THEN
     NEXT_STAC:=5;
ENDIF;

IF LENS_IN_STAC > 50 AND LENS_IN_STAC < 60 THEN
     NEXT_STAC:=6;
ENDIF;

IF LENS_IN_STAC > 60 AND LENS_IN_STAC < 70 THEN
     NEXT_STAC:=7;
ENDIF;
```

[0046]   As will be explained in greater detail below, the variables LENS_IN_STAC represents the current total amount of lens packages in the stack at any one time. The variable NEXT_STAC represents the next free stack position as determined. Therefore, as indicated in the same step, data is shifted from the package placement position {7} to the new position depending upon the current size of the stack. i.e.,

```
            IF NEXT_STAC >= 1 AND STACK_OCC[1] = 0 THEN
                 STACK_OCC[1]:=STACK_OCC[7];
                 STACK_ARR[1]:=STACK_ARR[7];
            ENDIF;

            IF NEXT_STAC >= 2 AND STACK_OCC[2] = 0 THEN
                 STACK_OCC[2]:=STACK_OCC[7];
                 STACK_ARR[2]:=STACK_ARR[7];
            ENDIF;

            IF NEXT_STAC >= 3 AND STACK_OCC[3] = 0 THEN
                 STACK_OCC[3]:=STACK_OCC[7];
                 STACK_ARR[3]:=STACK_ARR[7];
            ENDIF;

            IF NEXT_STAC >= 4 AND STACK_OCC[4] = 0 THEN
                 STACK_OCC[4]:=STACK_OCC[7];
                 STACK_ARR[4]:=STACK_ARR[7];
            ENDIF;

            IF NEXT_STAC >= 5 AND STACK_OCC[5] = 0 THEN
                 STACK_OCC[5]:=STACK_OCC[7];
                 STACK_ARR[5]:=STACK_ARR[7];
            ENDIF;

            IF NEXT_STAC >= 6 AND STACK_OCC[6] = 0 THEN
                 STACK_OCC[6]:=STACK_OCC[7];
                 STACK_ARR[6]:=STACK_ARR[7];
            ELSE
                 STACK_OCC[6]:=0;
                 STACK_ARR[6]:=0;
            ENDIF;

            IF NEXT_STAC >= 7 AND STACK_OCC[7] = 0 THEN
                 STACK_OCC[7]:=STACK_OCC[7];
                 STACK_ARR[7]:=STACK_ARR[7];
            ELSE
                 STACK_OCC[7]:=0;
                 STACK_ARR[7]:=0;
            ENDIF;
```

Note that the elapsed time and positional information from vacuum rail stack positions {7} will be re-initialized for the new process to occur at that position. Thus, STACK_OCC[7]:=0, indicates that there is an unoccupied position, due to consolidation, at location {7}. Additionally, STACK_ARR[7]:=0, indicates that there is no time stamp information at the location {7}.

[0047] Concurrent with or immediately after the next free position is calculated and the data is shifted, the packaging position cylinder is retracted at step 318 to align the lens packages present at position {1} so that the second buffer robot 60 may now pick a package array from that position.

Vacuum Rail to Package Dial or Buffer Delivery

[0048] Depending upon the status of the stack, i.e., the amount of lens packages at a first position thereof, and the status of the package index dial, and, the amount of lens packages buffer storage area, the robot gripper 65 of buffer robot 60 will pick up a 2 X 5 array of packages from position 57 of the vacuum rails A,B, (stack), and, depending upon the status condition of the lens packaging dial 200, will either place the packages on a support pallet positioned on the

package dial, or, will place the packages in one of fifty pallets 201 located at the buffer storage area 180 where the packages will be interimly stored until the package dial is ready to receive the array.

[0049]   As illustrated in the flow diagram of Figures 10(a)-(f), this determination is made by the PLC control system.

[0050]   In Figure 10(a), step 403 initializes software (math) subroutines and disables emergency stops (E-stops). If the lens package consolidation system is just starting up, the PLC initiates the robot pick and place sequences at step f3 and communicates the robot buffer robot home position, and buffer storage area good lens package pick-up position and, buffer storage area delivery positions, as indicated at step 403 in Figure 10(a). As part of the process for calculating the position in the buffer storage area where the robot could pick up a good lens package, a loop is executed where the PLC checks each buffer location CHK_POS to find a "1" in POS_OCC[CHK_POS] indicating a good lens package. When a one is found and this position is older than the oldest so far, i.e., the elapsed time POS_ARR[CHK_POS] is greater than the current oldest elapsed time, then the current POS_OCC[CHK_POS] will be declared the oldest. In the process for calculating a good delivery position for the robot, a loop is executed where the PLC checks the status of each buffer storage location (POS_OCC[CHK_POS]) to find a "0" in POS_OCC. A "0" indicates that the buffer position is free. When a zero is found, this position is assigned as the delivery position "DEL_POS". The subroutine is exited and a good lens package delivery position is ready to be communicated to the robot 60 at step 403.

[0051]   If the robot is not in an automatic run mode as determined at step 404, then the robot is commanded to go to a safe position at step 405 and the robot will be placed in a wait mode until the system is ready to run.

[0052]   In steady state, after lens package consolidation, the PLC control system will determine the status of the vacuum rail stack, the buffer storage area 180, and, in addition, check the status of the package dial 200 and the elapsed dry-time status up to this point of the package consolidation sequence, before enabling the buffer robot 60 to pick and place lens packages onto the package dial. As shown at step 410 in Figure 10(a), the PLC will first determine whether: the amount of packages at the buffer robot pickup point on the vacuum rails A,B is sufficient for the buffer robot to pick an array, whether the package index dial 200 is ready to receive the array from the vacuum rail stack, and, whether all software interlocks on the package dial are safe. If the above criteria are met, the PLC will make an additional determination as to whether good lens packages are present in the buffer storage area as shown at step 411.

[0053]   If lens packages are present in the buffer area as indicated at step 411, the PLC will communicate the good package pick-up position, as indicated by the variable G_PICK_POS, from one of the 42 positions in the buffer storage area, as indicated previously at step 403, and communicates the good package pick-up position to the buffer robot at step 414 which provide hand shaking at step 416. At step 417, the PLC initiates a start signal to enable the robot gripper to move to the buffer area lens package pick-up position and the robot will handshake an acknowledge signal at step 419.

[0054]   Steps 420 and 421 are next concurrently executed to prepare the robot for package pick-up. Specifically, step 421 initiates-handshaking between the PLC and the robot to enable vacuum to be supplied to the buffer robot gripper. At step 420, the PLC communicates the coordinates for the place position 8 at the package index table. At the following step 423, the elapsed dry time status and position information for the picked array of lens packages is moved from the buffer pick position represented in array POS_ARR[G_PICK_POS] to the robot tooling position which is always represented as array position 50, i.e., POS_ARR[50]. Note that the status is also put into position, i.e., POS_OCC[50] := POS_OCC[G_PICK_POS]. The timer and status information for the previously occupied good pick position POS_ARR [G_PICK_POS], POS_OCC[G_PICK_POS], respectively, is then re-initialized as containing no data (:= 0).

[0055]   The buffer robot is now ready to place the array of lens packages to position 8 of the index dial 200 and at step 425 it waits until the index dial is ready. Once the PLC determines that the index dial is ready, the start signal is given to the robot to execute the transfer of the package array to the package index dial at step 427 and the PLC waits for the robot gripper to reach its registered position. Next the vacuum for the robot gripper is turned off at step 439 and the package array is placed at the desired position on the index dial. At step 431, the position status information is transferred from the robot tooling position POS_OCC[50] to the index dial position 8, represented as IDX_OCC[8], which now retains the 2 X 5 array of lens packages. The data contained in the robot tooling position POS_ARR[50], POS_OCC[50] is reinitialized as containing no data. After the robot has dropped off the packages, the PLC commands the robot to retract from its position as indicated at step 433.

[0056]   In Figure 10(b) at step 435, a decision is made as to whether the buffer storage area is full lens package arrays or contains at least one lens package array. If the buffer area is full the process continues and at step 437, the package index dial is indexed to advance the package array to its next indexing position. If the buffer area contains at least one package array but is not full, the process continues and at step 439, the package index dial is released to advance to its next indexing position. Concurrently therewith, at step 441, the coordinates of the first pick-up position {1} on the stack (vacuum rails A,B), as illustrated in Figure 1, are communicated by the PLC to the buffer robot. The robot responds by moving into the robot received position at step 443. At step 445, the PLC waits for the stack ready signal indicating there is an array of lens packages waiting to be picked up by the robot. After receiving this signal, the robot is handshaked and receives a start signal at step 447 to move into the stack pick up position. When the robot reaches that position, the vacuum for the robot gripper is turned on at step 449. At step 451, the elapsed dry-time

information is shifted from the first position {1} of the vacuum rail, STACK_ARR[1], to the robot tooling position, POS_ARR[50]. Additionally, the lens package status information is shifted from the first position of the vacuum rail, STACK_OCC[1], to the robot tooling position, POS_OCC[50]. The time and status information for the first stack position STACK_ARR[1], STACK_OCC[1], respectively, is then re-initialized to a no data state.

[0057] Given the time and status data, the PLC determines if the lenses in the stack are good at step 453. If it is determined that the lenses are good, then the variable representing the total amount of lens packages in the stack, LENS_IN_STAC, is decremented by ten (10) at step 455. Next, the PLC commands the robot to move the lens package array from the first stack position {1} to a location in the buffer storage area 180. Thus, at step 457, the coordinates for the previously determined buffer delivery (place) position is communicated by the PLC to the buffer robot. After receiving the coordinates, the robot is handshaked and receives a start signal at step 459 to move into the stack pick up position. When the robot reaches that position and after appropriate handshaking, the vacuum for the robot gripper is turned off at step 461 and the packages are delivered to the buffer storage area. At step 463 the elapsed dry-time information for the picked array of lens packages is shifted from the robot tooling position POS_ARR[50] to the buffer delivery (place) position represented in array POS_ARR[DEL_POS]. Note that the elapsed dry time status information is also shifted accordingly, i.e., POS_OCC[DEL_POS] := POS_OCC[50]. The dry time and status information for the previously occupied robot tooling positions POS_ARR[50], POS_OCC[50], respectively, are re-initialized as containing no data. Next, at step 466 a determination is made as to whether the stack and the package index dial is or will soon be ready and robot is to be placed in its wait or "home" position. If so, the coordinates for the robot home position are communicated to the robot and the start signal for moving the robot to its home position is given at step 467. If it is determined at step 466 that the vacuum rail stack is ready to have a package array removed therefrom, and that the package index dial is ready to be serviced, then the process will start all over again at step 403 and the position variables and software interlocks are disabled.

[0058] If it is determined that the lens packages at the first stack position were bad, then the PLC commands the robot to move the lens package array from the first stack position to a predetermined scrap location 182 (POS_OCC [60]) in the buffer storage area 180 as shown symbolically in Figure 1. Thus, at step 469, the coordinates for the scrap delivery position is communicated by the PLC to the buffer robot. After receiving the coordinates, the robot is hand-shaked and receives a start signal at step 471 to move to the scrap delivery position. At step 473, the vacuum for the robot gripper is subsequently removed and the array of packages containing timed out lenses are scrapped at the scrap delivery position. The sequence is ready to begin again as indicated at step 403.

[0059] If lens packages are not present in the buffer area as determined at step 411, the PLC will communicate the coordinates of the stack pick-up position {1} to the buffer robot at step 472 in Figure 10(a). The robot responds by moving into the robot received position at step 475 and additionally the PLC waits for the stack ready signal indicating there is an array of lens packages waiting to be picked up by the robot. After receiving this signal, the robot is hand-shaked and receives a start signal at step 476 to move into the stack pick up position. When the robot reaches that position, the vacuum for the robot gripper is turned on at step 477. At step 478, the elapsed dry-time status information is shifted from the first position {1} of the vacuum rail 50, STACK_ARR[1], to the robot tooling position, POS_ARR[50]. Additionally, the lens package positional status is shifted from the first position of the vacuum rail, STACK_OCC[1], to the robot tooling position, POS_OCC[50]. The time and status information for the first stack position STACK_ARR(1], STACK_OCC[1], respectively, are then re-initialized to a no data state.

[0060] Given the time and status data, the PLC determines if the lenses in the stack were good at step 480. If it is determined that the lenses are good, then the variable representing the total amount of lens packages in the stack LENS_IN_STAC is decremented by ten (10) at step 482. Next, the PLC commands the robot to pick-up and transfer the lens package array from the first stack position to the index package dial delivery position. Thus, at step 484, the coordinates for the package index dial place position is communicated by the PLC to the buffer robot. After receiving the coordinates, the robot handshakes and then receives a start signal at step 486 to move into the package dial delivery position. When the robot reaches that position, the vacuum for the robot gripper is turned off at step 488 and the package array containing good lenses are delivered to the package dial 200. At step 489 in Figure 10(b), the elapsed dry-time information is transferred from the robot tooling position POS_OCC[50] to the index dial position 8, represented as IDX_OCC[8], which now retains the 2 X 5 array of lens packages. The data contained in the robot tooling position POS_ARR[50], POS_OCC[50] is reinitialized as containing no data. The robot is then retracted at step 491 and the steady state cycle is repeated.

[0061] If it is determined at step 480 that the lens packages at the first stack position are bad, then the PLC commands the robot to move the lens package array from the first stack position to a predetermined scrap location 182 (POS_OCC [60]) in the buffer storage area 180. Thus, at step 493, the coordinates for the scrap delivery position is communicated by the PLC to the buffer robot. After receiving the coordinates, the robot is handshaked and receives a start signal at step 495 to move to the scrap delivery position. At step 497, after the robot gripper has moved to the scrap delivery position, the vacuum for the robot gripper is removed, and the array of packages containing timed out lenses are scrapped. The sequence is ready to begin again as indicated at step 403.

Stack Ready, Deliver Package to Buffer Area

[0062] If the PLC determines that the vacuum rail stack is or may be ready with a package array for robot pick-up, but the indexing package dial is not ready to receive the array, then the following actions indicated from steps 510 to 558 in Figure 10(c) are performed. It should be noted that the indexing package dial may not be ready to receive an array for a variety of reasons, such as: package shingling, saline fluid level out of specification, inaccurate foil placement, etc. These conditions must be properly met before the heat seal die will extend to seal the package and index the package dial for moving the sealed package to the next station, as will be explained in greater detail below.

[0063] First, as indicated at step 511 in Figure 10(c), the coordinates of the first stacking (vacuum rail) position are read into the buffer robot and the PLC waits for the acknowledge signal. After receiving this signal, the robot handshakes an acknowledge signal at step 512 and receives a start signal at step 513 from the PLC to move into the stack pick up position. When the robot reaches that position, the vacuum for the robot gripper is turned on at step 515. At step 517, the time information is transferred from the first position {1} of the vacuum rail, STACK_ARR[1], to the robot tooling position, POS_ARR[50]. Additionally, the lens package status information is transferred from the first position of the vacuum rail, STACK_OCC[1], to the robot tooling position, POS_OCC[50]. The time and status information for the first stack position STACK_ARR[1], STACK_OCC[1], respectively, is then re-initialized to a no data state.

[0064] Given the time and status data, the PLC determines if the lenses in the stack were good at step 521. If it is determined that the lenses are good, then the variable representing the total amount of lens packages in the stack LENS_IN_STAC is decremented by ten (10) at step 523. Next, the PLC commands the robot to move the lens package array from the first stack position to a location in the buffer storage area 180. Thus, at step 525, the coordinates for an open buffer delivery (place) position is communicated by the PLC to the buffer robot. After receiving the coordinates, the robot is handshaked and receives a start signal at step 527 to move into the buffer delivery position. When the robot reaches that position, the vacuum for the robot gripper is turned off at step 529 and the package array containing good lenses are delivered to the buffer area 180. At step 531 the elapsed dry time information for the picked array of lens packages is moved from the robot tooling position POS_ARR[50] to the current buffer delivery (place) position represented in array POS_ARR[DEL_POS]. Note that the positional status information is also transferred accordingly, i.e., POS_OCC[DEL_POS] := POS_OCC[50]. The timer and status information for the previously occupied robot tooling positions POS_ARR[50], POS_OCC[50], respectively, are then re-initialized as containing no data. Next, at step 535 a determination is made as to whether the robot is to be placed in its wait or "home" position. If so, the coordinates for the robot home position are communicated to the robot at step 537 and the start signal for moving the robot to its home position is given at step 537 and the robot handshakes an acknowledge signal. If it is determined at step 535 that the vacuum rail stack is ready to have a package array removed therefrom, and that the package index dial is ready to be serviced, then the process will start all over again at step 403 and the position variables and software interlocks are disabled.

[0065] If it is determined at step 521 that the lens packages at the first stack position are bad, then the PLC commands the robot to move the lens package array from the first stack position to the predetermined scrap location 182 in the buffer storage area 180. Thus, at step 553, the coordinates for the scrap delivery position is communicated by the PLC to the buffer robot. After receiving the coordinates, the robot is handshaked and receives a start signal at step 556 to move to the scrap delivery position. At step 558, after the robot gripper has moved to the scrap delivery position, the vacuum for the robot gripper is removed and the array of packages containing timed out lenses are scrapped. The sequence is ready to begin again as indicated at step 403.

Buffer Area Package Delivery to Package Dial

[0066] If the PLC determines that the indexing package dial is or may soon be ready with a package array for robot pick-up, but the vacuum rail stack does not have a lens package array for robot pick-up, then the robot will be commanded to pick a good lens package array from the buffer area and place it on the indexing package dial as indicated from steps 610 in Figures 10(a) and 10(d). Thus, since the subroutine for calculating a good pick-up position in the buffer, G_PICK_POS, is executed at step 403, the PLC communicates the pick-up position to the buffer robot at step 611. At step 613, the PLC initiates a start signal to enable the robot gripper to move to the buffer area lens package pick-up position and the robot will handshake an acknowledge signal.

[0067] Steps 615 and 618 are next concurrently executed to prepare the robot for package pick-up. Specifically, at step 615 the PLC enables the vacuum to be supplied to the buffer robot gripper 65. At step 618, the PLC communicates the coordinates for the predetermined package place position at the indexing package table. At step 620, the elapsed dry time status for the picked array of lens packages is moved from the buffer pick position represented in array POS_ARR[G_PICK_POS] to the robot tooling position represented as POS_ARR[50]. Note that the dry time status is also put into position, i.e., POS_OCC[50] := POS_OCC[G_PICK_POS]. The timer and status information for the previously occupied good pick position POS_ARR[G_PICK_POS], POS_OCC[G_PICK_POS], respectively, is then re-

initialized as containing no data. The buffer robot is now ready to place the array of lens packages to the index package dial and at step 623 it waits until the index dial is ready. Once the PLC determines that the index dial is ready, the start signal is given to the robot to execute the transfer of the package array to the package index dial at step 625 and the PLC waits for the robot gripper to reach its commanded position. Next, after the gripper reaches its delivery position, the vacuum for the robot gripper is turned off at step 629 and the package array is placed at the desired position on the index dial. At step 631, the time information is transferred from the robot tooling position POS_OCC[50] to the index dial position 8, represented as IDX_OCC[8], which now retains the 2 X 5 array of lens packages. After the robot has dropped off the packages, the PLC commands the robot to retract from its position as indicated at step 633. At step 635, the package index dial is released to advance to its next indexing position and the robot returns to the beginning of the sequence at step 403 in Figure 10(a).

Buffer Area Bad Package Removal

[0068]   If the PLC determines that the indexing package dial is not requesting the need for a new lens package array because it has already been serviced, and, that the vacuum rail stack does not have a lens package array for robot pick-up, and furthermore, if it is determined that the buffer storage area has at least one array of packages that is bad and needs to be rejected, then the robot will be commanded to pick the bad lens package array from the buffer area and scrap it at the predetermined scrap location as indicated from steps 710-727 in Figures 10(a) and 10(e). The first step, indicated at step 711, is to calculate the bad lens package position in the buffer area so that the robot can scrap it. This is a software subroutine (not shown) that checks the positional status information represented as POS_OCC [CHK_POS] for each buffer position in the storage area. Specifically, the status POS_OCC[CHK_POS] of each position in the buffer area starting from the first position is checked to determine if it contains a value (for e.g., =2) indicating that that lens package is bad at that location. When a bad package position, represented as B_PICK_POS, has been determined, the PLC communicates that pick-up position to the buffer robot at step 713. At step 715, the PLC initiates a start signal to enable the robot gripper to move to the buffer area lens package pick-up position and the robot will handshake an acknowledge signal at step 717. Step 719 is next executed to prepare the robot for package pick-up. Specifically, at step 719, the PLC enables the vacuum to be supplied to the buffer robot gripper 65 so that the robot may pick up the bad lens package. Next, at step 721, the coordinates for the scrap delivery position is communicated by the PLC to the buffer robot. After appropriate robot handshaking, the robot receives a start signal at step 725 to move to the scrap delivery position. At this time, the data contained in the status variables for that particular buffer location POS_ARR[B_PICK_POS], and PPS_OCC[B_PICK_POS] is reinitialized as containing no data. At step 727, after the robot gripper has moved to the scrap delivery position, the vacuum for the robot gripper is removed and the array of packages containing timed out lenses are scrapped. The sequence is ready to begin again as indicated at step 403 in Figure 10(a).

[0069]   If the PLC determines that the indexing package dial is not requesting the need for a new lens package array because it has already been serviced, and, that the vacuum rail stack has at least one ready array of packages for robot pick-up and is not yet full of packages, and furthermore, if it is determined that the buffer storage area is full with good lens package arrays (that have not timed out), then the PLC will initiate the stack to be released, i.e., enable the pneumatic arm to push the most recently placed lens packages for consolidation at the front of the stack as indicated at step 810 in Figure 10(f). Then the cycle will again continue at step h1.

[0070]   As shown in further detail in Figure 11, after the 2 X 5 array of package carriers has been deposited on support pallet 201, the pallet is rotated to position 204 where optical sensors verify that a package has been loaded at each position and that the packages are correctly aligned on the pallet. Indexing turntable 200 is then rotated again to station 206 wherein each of the individual package carriers are dosed with approximately 950 microliter of a saline solution. The use of deionized water in the hydration and inspection steps significantly speeds the production line as a whole since the time consuming ionic neutralization of the polymer from which the lenses are made does not occur until after the inspection process. When deionized water is used for hydration and inspection, the final step of the process is to introduce buffered saline solution into the final package with the lens and then seal the lens within the package so that final lens equilibration (ionic neutralization, final hydration and final lens dimensioning) is accomplished in the package at room temperature or during sterilization after the lens has been packaged and sealed.

[0071]   As discussed in further detail in co-pending contemporaneously filed case VTN-93 (see item 19 on the attached Concordance), after saline dosing at station 206, the saline level is checked at station 208 by appropriate sensor 208a interfaced with the PLC 100 and the support pallet is then rotated under a final product check station (not shown) to a foil receiving station 210 where a foil pick and place unit, having an array of vacuum suction cups, lifts and places a sheet of laminated covers over the array of package bases. A suitable sensor 210a, interfaced with the PLC 100, is provided to ensure the placement of the foil is within tolerance. The packaging dial 200 is then rotated again to heat sealing station 212 where a heat seal mechanism 220 seals a single strip of foil to five separate package carriers in a single high temperature short cycle sealing operation. Packaging dial 200 is then rotated to position 214 where a

reciprocating transfer head 226 removes the sealed product from the packaging dial 200 and transports it in the direction of arrow D for sterilization and cartoning. If the saline fluid level or the placement of the foil is detected as not within predetermined specification, then the PLC will not index the rotary package dial 200 until corrective action is taken. Thus, packages at the consolidation buffer will be transferred for storage in the buffer area 180.

[0072] At the heat sealing radial station, an electrically heated seal head is supported by a pneumatic cylinder which presses the heated seal head against the laminated covers on the package bases. A thermocouple measures the temperature of the seal head to maintain the temperature in a range from 200-265°C. An in-line load cell measures the force generated by the pneumatic cylinder, and when a predetermined force is reached, which is a percentage of a possible maximum force, a timer is initiated. The timer times a relatively short time period of approximately 0.4 to 2.0 seconds, after which the pressure in the pneumatic cylinder is released, thereby forming a seal between each laminated cover and package base which is both detachable and customer friendly. The predetermined force is substantially 2700 newtons, which is approximately 75% of a maximum force of substantially 3600 newtons.

[0073] In operation, the back force generated by the pneumatic cylinder is measured by an in-line load cell (not shown) connected with the PLC, and a solid state timer is initiated when a force is reached of approximately 2700 newtons, which is approximately 75% of the peak force of approximately 3600 newtons. The solid state timer times a relatively short time period of approximately 0.4 to 2.0 seconds, after which the pressure in the pneumatic cylinder is released. This approach, when compared with similar prior art approaches, is very hot, very hard and very short, which creates a seal which is both detachable and customer friendly.

Claims

1. An interactive control system (11) constructed and arranged for controlling the automatic packaging of products in a product fabrication facility, said interactive control system comprising:

     (a) testing means (20) for determining whether the products are defective;
     (b) a first robot device (40) arranged for periodically transferring an individual array of a first predetermined amount of discrete products from a first station (20) to an intermediate conveyer (26) where said individual array is conveyed to a second station (25); wherein said first robot device (40) removes products from said array that have been determined to be defective by said testing means (20) prior to transfer to said intermediate conveyor (26) and wherein said intermediate conveyor (26) includes a mean (50) for consolidating the amount of products of said individual array transferred to said intermediate conveyor (26), said robot (40) device enabling said consolidating means (50) to consolidate said individual array of products and to ensure that a second predetermined amount of products is available for transfer to said second station (25); and
     (c) a controller (100) for tracking a time elapsed during conveyance of an individual array to said second station (25) and generating elapsed time data and position status data indicating a good array or a bad array of defective products for said individual array as it is conveyed to said second station (25), said controller shifting said elapsed time data and position status data for said individual array as it is conveyed on said intermediate conveyor (26) for transfer to said second station (26).

2. An interactive control system (11) for controlling the automatic packaging of products as claimed in claim 1, further including second robot device (60) for periodically transferring individual arrays of said second predetermined amount of individual products from said intermediate conveyor (50) for receipt at said second station, said controller (100) initiating rejection of said array of said second predetermined amount of products by said second robot device (60) when said shifted elapsed time data for that array is greater than a predetermined time limit.

3. An interactive control system (11) as claimed in claim 2, wherein said time limit is about 12 minutes to about 14 minutes.

4. An interactive control system (11) for controlling the automatic packaging of products as claimed in claim 2, wherein said second robot (60) rejects said individual array of said second predetermined amount of products at a predetermined scrap location.

5. An interactive control system (11) for controlling the automatic packaging of products as claimed in claim 2, wherein said controller (100) determines whether said second station (200) is available to receive said array of said second predetermined amount of products at said every period and further enable said second robot device to transfer said individual array of products of said second predetermined amount to an intermediate storage area (180) when it is determined that said second station (200) is not available to receive said array of second predetermined amount

of products.

6. An interactive control system (11) for controlling the automatic packaging of products as claimed in claim 4, wherein said controller (100) additionally shifts elapsed time data for each individual array of said second predetermined amount and shifts position status data for each individual array as it is transferred to said intermediate storage area (180).

7. An interactive control system (11) for controlling the automatic packaging of products as claimed in claim 5, wherein said controller (100) determines whether said second station (200) is available to receive said array of said second predetermined amount of products at said every period and further enables said second robot device (60) to transfer said individual array of products from said intermediate storage area (180) to said second station (200) when it is determined that an individual array of said second predetermined amount of products is good based on said positional status data.

8. An interactive control system (11) for controlling the automatic packaging of products as claimed in claim 5, wherein said controller (100) determines whether said second station (200) is available to receive said array of said second predetermined amount of products at said every period and further enables said second robot (60) device to transfer said individual array of products from said intermediate storage area (180) to said second station (200) when it is determined that an individual array of a second predetermined amount of products is not available for transfer from said intermediate conveyor (50).

9. An interactive control system (11) for controlling the automatic packaging of products as claimed in claim 1, wherein said individual array of said first predetermined amount of products are arranged in first row and second rows of products for conveyance on said intermediate conveyor (50), said first robot device (40) including means (45) for simultaneously gripping said first and second row prior to transferring said products to said intermediate conveyor (50).

10. An interactive control system (11) for controlling the automatic packaging of products as claimed in claim 9, wherein said intermediate conveyor (50) comprises first and second rails, said controller (100) enabling said first robot device (40) to transfer each first row of products to said first rail and said second row of products to said second rail, and further determines the amount of products transferred on each respective first and second rail at every period.

11. An interactive control system (11) for controlling the automatic packaging of products as claimed in claim 10, wherein said controller (100) enables said first robot device (40) to maintain the difference in the amount of products transferred to said first and second rail means to within a predetermined amount.

12. An interactive control system (11) for controlling the automatic packaging of products as claimed in claim 11, wherein said predetermined amount is one (1) package.

13. An interactive control system (11) for controlling the automatic packaging of products as claimed in claims 7 or 8, wherein said second station (200) includes an indexing package dial (200), said second robot device (60) transferring said individual array of said second predetermined amount of products to a predetermined location on said indexing dial.

14. An interactive control system (11) for controlling the automatic packaging of products as claimed in claim 13, wherein said controller (100) initiates said indexing package dial (200) to index said array of said second predetermined amount to a subsequent location after each array is transferred to said dial (200).

15. An interactive control system (11) according to any preceding claim wherein the products are contact lens packages.

16. An interactive control system (11) according to claim 15, wherein contact lenses are contained in a deionized water solution in said packages (15), said first station (25) including a deionized water removal device for removing said deionized water from each package (15) of said individual arrays prior to their transferrance from said first station (25).

17. An interactive control system (11) as claimed in claim 16, wherein said controller (100) generates said elapsed

time data when deionized water is removed from said packages (15).

18. An interactive control system (11) as claimed in claims 14 and 15, wherein said packages (15) are indexed on said indexing package dial (200) to a saline fill location where said packages (15) containing said contact lenses are filled with a saline solution.

19. An interactive control system (11) according to any preceding claim for controlling the consolidation of a serial product flow wherein said product flow includes a series of discrete product units, said control system (11) comprising:

(a) at least one serial product line (26) having random variations in serial product flow;
(b) a consolidation buffer (50) for receiving said serial products from said line (26);
(c) a controller (100) for initiating consolidation of said random variations in said product flow (26);
(d) an automated output means for selecting a predetermined number and arrangement of product units, and transporting said number and arrangement to a subsequent processing station:

20. An interactive control system (11) for controlling the consolidation of a serial product flow as claimed in claim 19, wherein said subsequent processing station is a product packaging index dial (200).

21. An interactive control system (11) for controlling the consolidation of a serial product flow as clamed in claim 20, wherein said subsequent processing station is an intermediate buffer storage area (180) for temporarily said products that have not could not be transported to said packaging index dial (200).

22. An interactive control system (11) for controlling the automatic packaging of contact lenses as claimed in any preceding claim, wherein said elapsed time data for each individual array and position status data indicating a good array or a bad array of defective lenses for each individual array is stored in a corresponding memory (102) location for said controller.

23. An interactive control system (11) for controlling the automatic packaging of contact lenses as claimed in claim 22, wherein said elapsed time data for each individual array and position status data are shifted in said controller memory (102) as said individual arrays are conveyed toward said second station.

Patentansprüche

1. Interaktives Steuerungssystem (11), aufgebaut und eingerichtet zum Steuern der automatischen Verpackung von Erzeugnissen in einer Anlage zur Herstellung derselben, wobei dieses interaktive Steuerungssystem umfaßt:

(a) eine Prüfeinrichtung (20) zur Feststellung, ob die Erzeugnisse fehlerhaft sind;

(b) eine erste Roboter-Einrichtung (40), die zum periodischen Überführen einer einzelnen Anordnung einer ersten vorgegebenen Anzahl einzelner Erzeugnisse von einer ersten Station (20) auf einen Zwischenförderer (26) eingerichtet ist, welcher die einzelne Anordnung zu einer zweiten Station (25) befördert, wobei die erste Roboter-Einrichtung (40) die von der Prüfeinrichtung (20) als fehlerhaft befundenen Erzeugnisse vor der Überführung auf den Zwischenförderer (26) aus der Anordnung entfernt, und wobei der Zwischenförderer (26) eine Einrichtung (50) zum Verdichten der Anzahl einzelner, auf den Zwischenförderer (26) überführter Erzeugnisse aufweist und der Roboter (40) die Verdichtungseinrichtung (50) veranlaßt, die einzelne Anordnung von Erzeugnissen zu verdichten und sicherzustellen, daß eine zweite vorgegebene Anzahl von Erzeugnissen zur Überführung zu der zweiten Station (25) verfügbar ist und

(c) eine Steuerungseinrichtung (100) zur Verfolgung des Zeitablaufes während der Beförderung einer einzelnen Anordnung zur zweiten Station (25) sowie zur Erzeugung von Zeitablaufdaten sowie von Positionszustandsdaten, welche anzeigen, ob eine gute Anordnung oder eine schlechte Anordnung fehlerhafter Erzeugnisse in der einzelnen Anordnung zur zweiten Station (25) befördert wird, wobei die Steuerungseinrichtung die Zeitablaufdaten und die Positionszustandsdaten für die einzelne Anordnung verschiebt, wenn letztere zur Überführung zur zweiten Station auf dem Zwischenförderer (26) befördert wird.

2. Interaktives Steuerungssystem (11) zum Steuern der automatischen Verpackung von Erzeugnissen nach An-

spruch 1, welches weiterhin eine zweite Roboter-Einrichtung (60) aufweist, um einzelne Anordnungen der zweiten vorgegebenen Anzahl einzelner Erzeugnisse periodisch vom Zwischenförderer (50) zur Übernahme an der zweiten Station zu überführen, wobei die Steuerungseinrichtung (100) die Zurückweisung der Anordnung der zweiten vorgegebenen Anzahl durch die zweite Roboter-Einrichtung (60) auslöst, wenn die Zeitablaufdaten für diese Anordnung größer sind als eine vorgegebene Zeitbegrenzung.

3. Interaktives Steuerungssystem (11) nach Anspruch 2, bei welchem die Zeitbegrenzung im Bereich von etwa 12 Minuten bis etwa 14 Minuten liegt.

4. Interaktives Steuerungssystem (11) zum Steuern der automatischen Verpackung von Erzeugnissen nach Anspruch 2, bei welchem der zweite Roboter (60) an einer vorgegebenen Abfallposition die einzelne Anordnung der zweiten vorgegebenen Anzahl von Erzeugnissen zurückweist.

5. Interaktives Steuerungssystem (11) zum Steuern der automatischen Verpackung von Erzeugnissen nach Anspruch 2, bei welchem die Steuerungseinrichtung (100) feststellt, ob die zweite Station (200) bereit ist, diese Anordnung der zweiten vorgegebenen Anzahl von Erzeugnissen in jeder Periode aufzunehmen und weiterhin die zweite Roboter-Einrichtung (60) veranlaßt, die einzelne Anordnung von Erzeugnissen der zweiten vorgegebenen Anzahl in einen Zwischenspeicherbereich (180) zu überführen, wenn festgestellt wird, daß die zweite Station (200) die Anordnung der zweiten vorgegebenen Anzahl an Erzeugnissen nicht aufnehmen kann.

6. Interaktives Steuerungssystem (11) zum Steuern der automatischen Verpackung von Erzeugnissen nach Anspruch 4, bei welchem die Steuerungseinrichtung (100) zusätzlich die Zeitablaufdaten für jede einzelne Anordnung der zweiten vorgegebenen Anzahl sowie die Positionszustandsdaten für jede einzelne Anordnung verschiebt, wenn sie in den Zwischenspeicherbereich (180) überführt wird.

7. Interaktives Steuerungssystem (11) zum Steuern der automatischen Verpackung von Erzeugnissen nach Anspruch 5, bei welchem die Steuerungseinrichtung (100) feststellt, ob die zweite Station (200) bereit ist, die Anordnung der zweiten vorgegebenen Anzahl von Erzeugnissen in jeder Periode aufzunehmen und ob weiterhin die zweite Roboter-Einrichtung (60) freigegeben ist, die einzelne Anordnung von Erzeugnissen aus dem Zwischenspeicherbereich (180) zur zweiten Station (200) zu überführen, wenn an Hand der Positionszustandsdaten festgestellt wird, daß eine einzelne Anordnung der zweiten Anzahl von Erzeugnissen gut ist.

8. Interaktives Steuerungssystem (11) zum Steuern der automatischen Verpackung von Erzeugnissen nach Anspruch 5, bei welchem die Steuerungseinrichtung (100) feststellt, ob die zweite Station (200) bereit ist, die Anordnung der zweiten vorgegebenen Anzahl von Erzeugnissen in jeder Periode aufzunehmen und ob weiterhin die zweite Roboter-Einrichtung (60) veranlaßt, die einzelne Anordnung von Erzeugnissen aus dem Zwischenspeicherbereich (180) zur zweiten Station (200) zu überfuhren, wenn festgestellt wird, daß keine einzelne Anordnung der zweiten Anzahl von Erzeugnissen zur Überführung vom Zwischenförderer (50) verfügbar ist.

9. Interaktives Steuerungssystem (11) zum Steuern der automatischen Verpackung von Erzeugnissen nach Anspruch 1, bei welchem die einzelne Anordnung der ersten vorgegebenen Anzahl von Erzeugnissen für die Beförderung auf dem Zwischenförderer (50) in einer ersten und einer zweiten Reihe von Erzeugnissen angeordnet wird, wobei die erste Roboter-Einrichtung (40) eine Einrichtung (45) zum gleichzeitigen Ergreifen der ersten und der zweiten Reihe vor der Überführung der Erzeugnisse auf den Zwischenförderer (50) aufweist.

10. Interaktives Steuerungssystem (11) zum Steuern der automatischen Verpackung von Erzeugnissen nach Anspruch 9, bei welchem der Zwischenförderer (50) eine erste und eine zweite Schiene umfaßt und die Steuerungseinrichtung (100) die erste Roboter-Einrichtung (40) veranlaßt, jeweils die erste Reihe der Erzeugnisse auf die erste Schiene und die zweite Reihe der Erzeugnisse auf die zweite Schiene zu überführen und jene weiterhin die Anzahl der in jeder Periode auf die erste und die zweite Schiene überführten Erzeugnisse feststellt.

11. Interaktives Steuerungssystem (11) zum Steuern der automatischen Verpackung von Erzeugnissen nach Anspruch 10, bei welchem die Steuerungseinrichtung (100) die erste Roboter-Einrichtung (40) veranlaßt, die Differenz der Anzahl der auf die erste und auf die zweite Schiene überführten Erzeugnisse unterhalb eines vorgegebenen Wertes zu halten.

12. Interaktives Steuerungssystem (11) zum Steuern der automatischen Verpackung von Erzeugnissen nach Anspruch 11, bei welchem der vorgegebene Wert eine Packung beträgt.

13. Interaktives Steuerungssystem (11) zum Steuern der automatischen Verpackung von Erzeugnissen nach Anspruch 7 oder 8, bei welchem die zweite Station (200) einen Verpakkungs-Rundschalttisch (200) aufweist und die zweite Roboter-Einrichtung (60) die einzelne Anordnung der zweiten vorgegebenen Anzahl von Erzeugnissen in eine vorgegebene Position auf dem Rundschalttisch überführt.

14. Interaktives Steuerungssystem (11) zum Steuern der automatischen Verpackung von Erzeugnissen nach Anspruch 13, bei welchem die Steuerungseinrichtung (100) den Verpakkungs-Rundschalttisch (200) auslöst, um die Anordnung der zweiten vorgegebenen Anzahl von Erzeugnissen, jeweils nachdem sie auf den Rundschalttisch (200) überführt wurde, zur nachfolgenden Position weiterzuschalten

15. Interaktives Steuerungssystem (11) nach einem der bisherigen Ansprüche, bei welchem die Erzeugnisse Kontaktlinsenpackungen sind.

16. Interaktives Steuerungssystem (11) nach Anspruch 15, bei welchem sich die Kontaktlinsen in den Packungen (15) in einer Lösung entionisierten Wassers befinden, wobei die erste Station (25) eine Einrichtung zum Entfernen des entionisierten Wassers aus jeder Packung (15) der einzelnen Anordnungen vor der Überführung von der ersten Station (25) aufweist.

17. Interaktives Steuerungssystem (11) nach Anspruch 16, bei welchem die Steuerungseinrichtung (100) die Zeitablaufdaten erzeugt, wenn das entionisierte Wasser aus den Packungen (15) entfernt wird.

18. Interaktives Steuerungssystem (11) nach Anspruch 14 und 15, bei welchem die Packungen (15) auf dem Verpakkungs-Rundschalttisch (200) zu einer Salzlösungs-Füllstation weitergeschaltet werden, wo die Packungen (15), welche die Kontaktlinsen enthalten, mit einer Salzlösung gefüllt werden.

19. Interaktives Steuerungssystem (11) nach einem der bisherigen Ansprüche zur Steuerung der Verdichtung eines seriellen Erzeugnis-Stromes, bei welchem der Erzeugnis-Strom eine Serie einzelner Erzeugnis-Einheiten enthält, wobei die Steuerungseinrichtung (100) umfaßt:

    (a) mindestens eine serielle Erzeugnis-Linie (26) mit zufälligen Schwankungen im seriellen Erzeugnis-Strom;

    (b) einen Verdichtungspuffer (50) zur Aufnahme der seriellen Erzeugnisse von der Linie (26);

    (c) eine Steuerungseinrichtung (100) zum Auslösen der Verdichtung der zufälligen Schwankungen im Erzeugnis-Strom (26);

    (d) eine automatische Ausgabe-Einrichtung zur Auswahl einer vorgegebenen Anzahl und Anordnung von Erzeugnis-Einheiten sowie zum Transport dieser Anzahl und Anordnung zu einer nachfolgenden Bearbeitungsstation.

20. Interaktives Steuerungssystem (11) zur Steuerung der Verdichtung eines seriellen Erzeugnis-Stromes nach Anspruch 19, bei welchem die nachfolgende Bearbeitungsstation ein Erzeugnis-Verpackungs-Rundschalttisch (200) ist.

21. Interaktives Steuerungssystem (11) zur Steuerung der Verdichtung eines seriellen Erzeugnis-Stromes nach Anspruch 20, bei welchem die nachfolgende Bearbeitungsstation ein Zwischen-Pufferlagerungsbereich (180) zur zeitweiligen Lagerung derjenigen Erzeugnisse ist, die nicht zum Verpackungs-Rundschalttisch (200) transportiert werden konnten.

22. Interaktives Steuerungssystem (11) zur Steuerung der automatischen Verpackung von Kontaktlinsen nach einem der bisherigen Ansprüche, bei welchem die Zeitablaufdaten für jede einzelne Anordnung sowie die Positionszustandsdaten, welche eine gute Anordnung oder eine schlechte Anordnung fehlerhafter Linsen anzeigen, für jede einzelne Anordnung in einer entsprechenden Position des Speichers (102) für die Steuerungseinrichtung (100) gespeichert werden.

23. Interaktives Steuerungssystem (11) zur Steuerung der automatischen Verpackung von Kontaktlinsen nach Anspruch 22, bei welchem die Zeitablaufdaten für jede einzelne Anordnung sowie die Positionszustandsdaten im Speicher (102) der Steuerungseinrichtung verschoben werden, wenn die einzelnen Anordnungen zur zweiten Sta-

tion befördert werden

Revendications

1. Un système de commande interactif (11) construit et agencé pour commander l'emballage automatique de produits dans une installation de fabrication de produits, ledit système de commande interactif comprenant:

    (a) un moyen de test (20) pour déterminer si les produits sont défectueux;

    (b) un premier dispositif robotique (40) agencé pour transférer périodiquement un ensemble individuel d'une première quantité prédéterminée de produits discrets d'une première station (20) vers un transporteur intermédiaire (26) où ledit ensemble individuel est transporté vers une deuxième station (25); dans lequel ledit premier dispositif robotique (40) enlève, dudit ensemble, des produits qui ont été déterminés comme défectueux par ledit moyen de test (20) avant le transfert vers ledit transporteur intermédiaire (26) et dans lequel ledit transporteur intermédiaire (26) inclut un moyen de groupage (50) de la quantité de produits dudit ensemble individuel transféré vers ledit transporteur intermédiaire (26), ledit dispositif robotique (40) permettant audit moyen de groupage (50) de grouper ledit ensemble individuel de produits et d'assurer qu'une deuxième quantité prédéterminée de produits est disponible pour transfert vers ladite deuxième station (25); et

    (c) un dispositif de commande (100) pour garder un suivi d'un temps écoulé pendant le transport d'un ensemble individuel vers ladite deuxième station (25) et engendrer des données de temps écoulé et des données d'état de position qui indiquent que ledit ensemble individuel est un bon ensemble ou un mauvais ensemble constitué de produits défectueux tandis qu'il est transporté vers ladite deuxième station (25), ledit dispositif de commande décalant lesdites données de temps écoulé et lesdites données d'état de position pour ledit ensemble individuel tandis qu'il est transporté sur ledit transporteur intermédiaire (26) pour transfert vers ladite deuxième station (26).

2. Un système de commande interactif (11) pour commander l'emballage automatique de produits selon la revendication 1, qui inclut en outre un deuxième dispositif robotique (60) pour transférer périodiquement des ensembles individuels de ladite deuxième quantité prédéterminée de produits individuels à partir dudit transporteur intermédiaire (50) pour réception à ladite deuxième station, ledit dispositif de commande (100) lançant un rejet dudit ensemble de ladite deuxième quantité prédéterminée de produits par ledit deuxième dispositif robotique (60) lorsque lesdites données décalées de temps écoulé pour cet ensemble sont supérieures à une limite de temps prédéterminée.

3. Un système de commande interactif (11) selon la revendication 2 dans lequel ladite limite de temps est d'environ 12 minutes à environ 14 minutes.

4. Un système de commande interactif (11) pour commander l'emballage automatique de produits selon la revendication 2, dans lequel ledit deuxième robot (60) rejette ledit ensemble individuel de ladite deuxième quantité prédéterminée de produits à un emplacement prédéterminé de rebut.

5. Un système de commande interactif (11) pour commander l'emballage automatique de produits selon la revendication 2, dans lequel ledit dispositif de commande (100) détermine si ladite deuxième station (200) est disponible pour recevoir ledit ensemble de ladite deuxième quantité prédéterminée de produits à chacune desdites périodes et permettre en outre au deuxième dispositif robotique de transférer ledit ensemble individuel de produits de ladite deuxième quantité prédéterminée vers une zone de magasinage intermédiaire (180) lorsqu'il est déterminé que ladite deuxième station (200) n'est pas disponible pour recevoir ledit ensemble de la deuxième quantité prédéterminée de produits.

6. Un système de commande interactif (11) pour commander l'emballage automatique de produits selon la revendication 4, dans lequel ledit dispositif de commande de commande (100) décale de plus des données de temps écoulé pour chaque ensemble individuel de ladite deuxième quantité prédéterminée et décale des données d'état de position pour chaque ensemble individuel tandis qu'il est transféré vers ladite zone de magasinage intermédiaire (180).

7. Un système de commande interactif (11) pour commander l'emballage automatique de produits selon la revendication 5, dans lequel ledit dispositif de commande (100) détermine si ladite deuxième station (200) est disponible pour recevoir ledit ensemble de ladite deuxième quantité prédéterminée de produits à chacune desdites périodes

et permet en outre audit deuxième dispositif robotique (60) de transférer ledit ensemble individuel de produits à partir de ladite zone de magasinage intermédiaire (180) vers ladite deuxième station (200) lorsqu'il est déterminé, sur la base desdites données d'état de position, qu'un ensemble individuel de ladite deuxième quantité prédéterminée de produits est bon.

8. Un système de commande interactif (11) pour commander l'emballage automatique de produits selon la revendication 5, dans lequel ledit dispositif de commande (100) détermine si la deuxième station (200) est disponible pour recevoir ledit ensemble de ladite deuxième quantité prédéterminée de produits à chacune desdites périodes et permet en outre audit deuxième dispositif robotique (60) de transférer ledit ensemble individuel de produits à partir de ladite zone de magasinage intermédiaire (180) vers ladite deuxième station (200) lorsqu'il est déterminé qu'un ensemble individuel d'une deuxième quantité prédéterminée de produits n'est pas disponible pour transfert à partir dudit transporteur intermédiaire (50).

9. Un système de commande interactif (11) pour commander l'emballage automatique de produits selon la revendication 1, dans lequel ledit ensemble individuel de ladite première quantité prédéterminée de produits est agencé dans une première et une deuxième rangées de produits pour transport sur ledit transporteur intermédiaire (50), ledit premier dispositif robotique (40) incluant un moyen (45) de saisie simultanée desdites première et deuxièmes rangées avant de transférer lesdits produits vers ledit transporteur intermédiaire (50).

10. Un système de commande interactif (11) pour commander l'emballage automatique de produits selon la revendication 9, dans lequel ledit transporteur intermédiaire (50) comprend un premier et un deuxième rails, ledit dispositif de commande (100) permettant audit premier dispositif robotique (40) de transférer chacune desdites premières rangées de produits vers ledit premier rail et chacune desdites deuxièmes rangées de produits vers ledit deuxième rail, et détermine en outre la quantité de produits transférés à chaque période sur chacun des premier et deuxième rails respectifs.

11. Un système de commande interactif (11) pour commander l'emballage automatique de produits selon la revendication 10, dans lequel ledit dispositif de commande (100) permet audit premier dispositif robotique (40) de maintenir égale ou inférieure à une quantité prédéterminée la différence entre les quantités de produits transférés vers ledit premier et ledit deuxième moyens de rails.

12. Un système de commande interactif (11) pour commander l'emballage automatique de produits selon la revendication 11, dans lequel ladite quantité prédéterminée est de un (1) emballage.

13. Un système de commande interactif (11) pour commander l'emballage automatique de produits selon la revendication 7 ou 8, dans lequel ladite deuxième station (200) inclut un plateau tournant indexable (200) de conditionnement, ledit deuxième dispositif robotique (60) transférant ledit ensemble individuel de ladite deuxième quantité prédéterminée de produits vers un emplacement prédéterminé sur ledit plateau tournant indexable.

14. Un système de commande interactif (11 pour commander l'emballage automatique de produits selon la revendication 13, dans lequel ledit dispositif de commande (100) lance ledit plateau tournant indexable de conditionnement (200) pour indexer ledit ensemble de ladite deuxième quantité prédéterminée à un emplacement ultérieur, après transfert de chaque ensemble vers ledit plateau tournant (200).

15. Un système de commande interactif (11) selon l'une quelconque des revendications précédentes dans lequel les produits sont des emballages de lentilles de contact.

16. Un système de commande interactif (11) selon la revendication 15 dans lequel des lentilles de contact sont contenues dans une solution d'eau désionisée dans lesdits emballages (15), ladite première station (25) inclut un dispositif d'enlèvement d'eau désionisée pour enlever l'eau désionisée de chaque emballage (15) desdits ensembles individuels avant leur transfert à partir de ladite première station (25).

17. Un système de commande interactif (11) selon la revendication 16, dans lequel ledit dispositif de commande (100) engendre lesdites données de temps écoulé lorsque l'eau désionisée est enlevée desdits emballages (15).

18. Un système de commande interactif (11) selon la revendication 14 et 15, dans lequel lesdits emballages (15) sont indexés sur ledit plateau tournant indexable (200) de conditionnement à un emplacement de remplissage salin où lesdits emballages (15) qui contiennent lesdites lentilles de contact sont remplis d'une solution saline.

19. Un système de commande interactif (11) selon l'une quelconque des revendication précédentes destiné à commander le groupage d'un flux sériel de produits dans lequel ledit flux de produits comprend une série d'unités discrètes de produit, ledit système de commande (11) comprenant:

(a) au moins une ligne sérielle (26)de produits où des variations aléatoires apparaissent dans ledit flux sériel de produits;
(b) un tampon de groupage (50) pour enlever de ladite ligne (26) lesdits produits sériels;
(c) un dispositif de commande (100) pour lancer un équilibrage desdites variations aléatoires dans ledit flux (26) de produits;
(d) un moyen de sortie automatisé pour sélectionner un nombre et un agencement prédéterminés d'unités de produits et pour transporter ledit nombre et ledit agencement vers une station ultérieure de traitement.

20. Un système de commande interactif (11) destiné à commander le groupage d'un flux sériel de produits selon la revendication 19, dans lequel ladite station de traitement ultérieure est un plateau tournant indexable (200) de conditionnement de produits.

21. Un système de commande interactif (11) destiné à commander le groupage d'un flux sériel de produits selon la revendication 20, dans lequel ladite station de traitement ultérieure est une zone de magasinage tampon intermédiaire (180) pour emmagasiner temporairement lesdits produits qui n'auraient pas pu être transportés vers ledit plateau tournant indexable (200) de conditionnement.

22. Un système de commande interactif (11) destiné à commander l'emballage automatique de lentilles de contact selon l'une quelconque des revendications précédentes, dans lequel lesdites données de temps écoulé pour chaque ensemble individuel et lesdites données d'état de position qui indiquent pour chaque ensemble individuel si c'est un bon ou un mauvais ensemble constitué de lentilles défectueuses sont mémorisées dans un emplacement d'une mémoire correspondante (102) destinée audit dispositif de commande.

23. Un système de commande interactif (11) destiné à commander l'emballage individuel de lentilles de contact selon la revendication 22, dans lequel lesdites données de temps écoulé pour chaque ensemble individuel et lesdites données d'état de position sont décalées dans ladite mémoire (102) du dispositif de commande au fur et à mesure que lesdits ensembles individuels sont transportés vers ladite deuxième station.
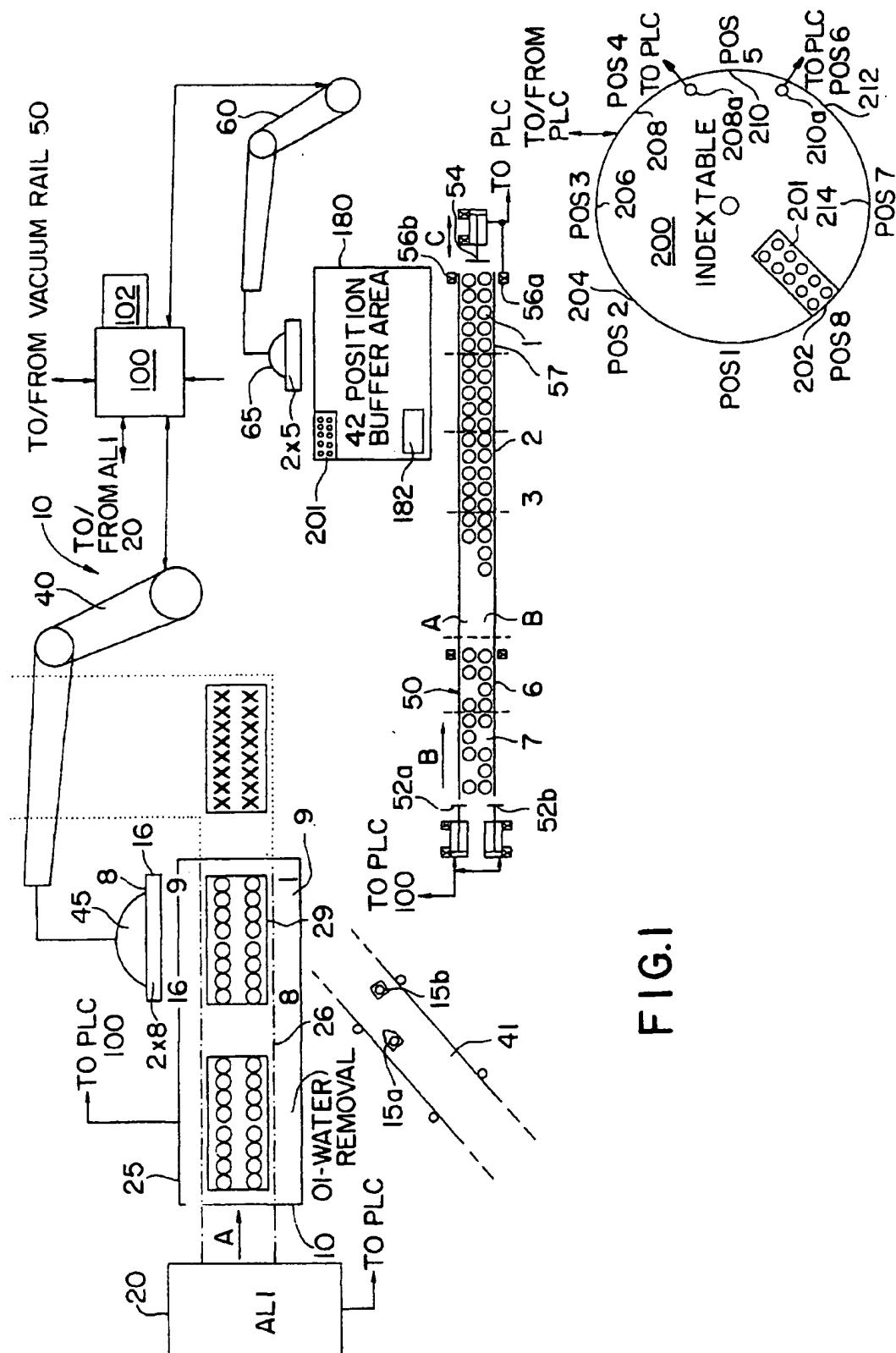
FIG.1

F I G.2

F I G.3

FIG.4

FIG.5

FIG.6

START

DI BLOW
PRESSURE CHECK — 71

AIR BLOW
CYLINDER DOWN — 73

INIT. BLOW — 75

STOP BLOW — 77

AIR BLOW
CYLINDER UP — 79

START TIME STAMP
POS_ARR[IO]=I
POS_OCC[IO]=I — 81

END

FIG. 7A

START

FROM STEP 183

111 — INITIALIZE

113 — WAIT FOR START

115 — LENSES OLD ?

N

Y

117 — SET BIT POSITION

167 — SET BIT POSITION

119 — WAIT FOR ROBOT HANDSHAKE

169 — WAIT FOR HANDSHAKE

121 — START ROBOT

171 — APPLY VACUUM B PICK UP LENSES IN B

123 — WAIT UNTIL ROBOT REACHES POSITION

173 — APPLY VACUUM SIDE A

125 — APPLY VACUUM TO LINE B PICK-UP LENSES IN LINE B

176 — SET BIT REJECT POSITION

127 — APPLY VACUUM TO LINE PICK-UP LENSES IN LINE A

177 — WAIT FOR HANDSHAKE

129 — SHIFT DATA

178 — START ROBOT

GO TO STEP 131

179 — ROBOT REACH POSITION

181 — DUMP PACKAGES

GO TO STEP 111

183 — RETURN ROBOT HOME

FIG.7B

FROM STEP 129

SET BIT
POSITION — 131

WAIT FOR
HANDSHAKE — 133

START ROBOT — 135

WAIT TILL
REACH
POSITION — 137

DETERMINE IF
BAD LENSES — 139

139a

Y — RO_STAT_A<255
RO_STAT_B<255 — N

142 — DUMP BAD
PACKAGES

142a

RO_STAT_A =0
RO_STAT_B =0 — N

Y

143 — RETURN TO
HOME
POSITION

GO TO
STEP III

VACUUM
RAIL
READY — 145

SET BIT
POSITION 7 — 147

WAIT FOR
HANDSHAKE — 149

START ROBOT — 151

GO TO
STEP 153

F I G. 7C

FROM STEP 151

WAIT TILL
REACH ——153

CALCULATE #
DIFF.
BETWEEN
ROW A & B ——155

FIND THE
POSITIONS
AND BALANCE
RAIL A&B ——157

——159

TRANSFER
FROM
A TO B
?   N

Y

161—— SET ROBOT
BIT POSITION

162——
SET ROBOT
BIT POSITION

163—— PLACE
PACKAGES

165—— SHIFT
DATA

FIG.8A

START

202 — i=1, j=1
NUMB_A := 0
NUMB_B := 0

204 — VAC_ARR_A[i] GOOD? — Y → 206 — NUMB_A := NUMB_A +1

N

215 — i = i+1
j = j+1

208 — VAC_ARR_B[j] GOOD? — Y → 211 — NUMB_B = NUMB_B +1

N

213 — i = 8
j = 8
? — Y

N

217 — TOTAL := NUMB_A + NUMB_B

219 — NUMB_A > NUMB_B — Y → 221 — DIFF_A = NUM_A − NUM_B

N

223 — NUMB_B > NUMB_A — Y → 226 — DIFF_B = NUMB_B − NUMB_A

N

228 — NO NEED TO BALANCE VAC. RAILS A, B

TO FIG.8B

F I G.8B

From Fig. 8A

229 — DIFF_A > DIFF_B — Y — 231 — DIFF_A >= 2 — Y

N   N

232 — NO NEED TO BALANCE

233 — MOVE_A:=DIFF_A/2

GO TO STEP 243

236 — DIFF_B > DIFF_A — Y — 238 — DIFF_B >= 2 — Y

241 — NO NEED TO BALANCE

239 — MOVE_B:=DIFF_B/2

GO TO STEP 253

F I G. 8C

FROM STEP 233
FIG.8B

i = I, j = I
FRE_FOU_A = O ⎯ 243

245

VACC_ARR_A[i] ≠
VACC_ARR_B[j] — Y → 247 — Y → FRE_FOU_A <
MOVE_A

N

j = j+I
i = i+I ⎯ 244

N

248
FRE_FOU_A =
FRE_FOU_A + I

249
MOV_ARR [I] := TRUE

246
i = 8? — Y → END

N

FIG.8D

FROM STEP 239

i=l, j=l
FRE_FOU_B = 0   —253

255

VACC_ARR_B[j]≠
VACC_ARR_A[i]
?

Y

257—

FRE_FOU_B<
MOVE_B

Y

N

N

j=j+l
i=i+l   —263

258—

FRE_FOU_B =
FRE_FOU_B + l;
MOV_ARR[I]:=TRUE

259

261

j = 8?

Y

END

N

FIG.9

FIG.IOA-1

S

403 — INITIALIZE

404 — IN AUTO RUN MODE? — N → 405 ROBOT GO TO SAFE CALIBRATION POS.

Y

410 — STACK READY AND INDEX DIAL READY? — N → 510 STACK READY; INDEX DIAL NOT READY? — Y → GO TO FIG.IOC

N

610 — INDEX DIAL READY; STACK NOT? — Y → GO TO FIG.IOD

N

710 — INDEX NOT READY, STACK NOT READY; BUFFER AREA HAS BAD LENS PKG.? — N → GO TO FIG.IOF

Y → GO TO FIG.IOE

411 — GOOD LENSES IN BUFFER AREA?

Y:
414 — COMMUNICATE GOOD POS. TO ROBOT
416 — ROBOT HANDSHAKE
417 — START AND MOVE ROBOT TO PICK UP
419 — ROBOT HANDSHAKE

N:
474 — COMMUNICATE STACK PICK POSITION
476 — WAIT FOR ROBOT HANDSHAKE
477 — START AND MOVE ROBOT

FIG.IOA-2

420
COMMUNICATE
INDEX TABLE
PLACE POSITION
TO ROBOT

421
APPLY VACUUM
TO ROBOT
GRIPPER

APPLY VACUUM
TO ROBOT
GRIPPER — 478

423
SHIFT ELAPSED
TIME AND POS.
STATUS TO
ROBOT GRIP
POSITION

SHIFT ELAPSED
TIME AND POS.
DATA — 479

425
WAIT FOR
INDEX DIAL
READY SIGNAL

480
GOOD
LENSES
IN ROBOT
GRIP?   N

427
START
ROBOT

Y   482
DECREMENT
LENS_IN_STACK

493
COMMUNICATE
SCRAP PACKAGE
POSITION

429
REMOVE VACUUM
DROP PACKAGE
ON INDEX DIAL

484
COMMUNICATE
INDEX DIAL
PLACE POSITION

495
START AND
MOVE ROBOT
TO DIAL

431
MOVE POSITION
STATUS
INFORMATION
TO INDEX
DIAL POSITION

486
START AND
MOVE ROBOT
TO DIAL

497
REMOVE VACUUM
SCRAP PACKAGE
ARRAY

433
RETRACT ROBOT

488
DROP PACKAGE
ARRAY_REMOVE
ROBOT VACUUM

GO TO STEP
403

GO TO STEP
435, FIG.IOB

GO TO
STEP 489

FIG.10B

FROM STEP 433,FIG.10A

FROM STEP 488

```
                                    435
                        IS
                N     BUFFER
                       FULL
                         ?
                         │ Y
           437          │
                   ┌──────────┐
                   │  INDEX   │
                   │ PACKAGE  │
                   │   DIAL   │
                   └──────────┘
                        │
                   GO TO
                   STEP 403
```

```
                         439
                   ┌──────────┐
                   │  INDEX   │
                   │ PACKAGE  │
                   │   DIAL   │
                   └──────────┘
                        │
                   ┌──────────────┐
                   │ COMMUNICATE  │      441
                   │ STACK PICK-UP│
                   │  POSITION    │
                   └──────────────┘
                        │
                   ┌──────────────┐
                   │  WAIT FOR    │      443
                   │ROBOT HANDSHAKE│
                   └──────────────┘
                        │
                   ┌──────────────┐
                   │  WAIT FOR    │      445
                   │ STACK READY  │
                   │   SIGNAL     │
                   └──────────────┘
```

447 ─ START ROBOT MOVE TO PICK-UP

449 ─ TURN GRIPPER VACUUM ON

451 ─ SHIFT ELAPSED TIME AND POSITION DATA

```
           453          GOOD
                       LENSES IN     N
                       ROBOT GRIP
                         ?
                         │ Y
```

455 ─ DECREMENT LENS-IN-STAC

457 ─ COMMUNICATE BUFFER AREA DELIVERY POSITION

459 ─ START AND MOVE ROBOT TO DELIVERY POSITION

461 ─ REMOVE VACUUM DELIVERY PACKAGE ARRAY

463 ─ SHIFT ELAPSED DRY-TIME AND POSITION DATA

```
                   ┌──────────────┐
                   │ MOVE ELAPSED │     489
                   │  TIME AND    │
                   │POSITION DATA │
                   └──────────────┘
                        │
                   ┌──────────────┐
                   │   RETRACT    │     491
                   │    ROBOT     │
                   └──────────────┘
                        │
                   GO TO STEP
                   403 FIG.10A
```

GO TO STEP 403

473 ─ REMOVE VACUUM SCRAP PACKAGE ARRAY

471 ─ START AND MOVE ROBOT TO SCRAP

469 ─ COMMUNICATE SCRAP PACKAGE POSITION

```
                   GO TO STEP
                   403,FIG.10A
                                        467
                   ┌──────────────┐
                   │ MOVE ROBOT   │
                   │TO HOME POS.  │
                   └──────────────┘
                        │ N
                                        466
                        STACK
                        AND INDEX       Y
                        DIAL READY
                          ?
                   GO TO STEP
                   403,FIG.10A
```

40

FROM STEP 510
FIG.IOA

FIG.IOC

511 — COMMUNICATE
STACK PICK-UP
POSITION

512 — WAIT FOR
ROBOT HANDSHAKE

513 — START AND
MOVE ROBOT

515 — APPLY VACUUM
TO ROBOT
GRIPPER

517 — SHIFT ELAPSED
TIME AND
POSITION DATA

521 — GOOD
LENSES IN
ROBOT GRIP
? — N

Y

523 — DECREMENT
LENS-IN-STAC

525 — COMMUNICATE
BUFFER AREA
PLACE POSITION

527 — START AND
MOVE ROBOT
TO DIAL

529 — DROP PACKAGE
ARRAY_REMOVE
ROBOT VACUUM

531 — SHIFT ELAPSED
DRY-TIME AND
POSITION DATA

GO TO STEP 403

REMOVE VACUUM
SCRAP PACKAGE
ARRAY — 558

START AND
MOVE ROBOT
TO DIAL — 556

COMMUNICATE
SCRAP PACKAGE
POSITION — 553

GO TO STEP
403,FIG.IOA

537 —
MOVE ROBOT
TO HOME POS.

N

535 —
STACK
AND INDEX
DIAL READY
? — Y

GO TO STEP
403,FIG.IOA

FIG.IOD

FROM STEP 610
FIG.IOA

611 — COMMUNICATE
BUFFER AREA
PICK-UP POSITION

613 — START AND
MOVE ROBOT
TO PICK-UP
POSITION

615 — APPLY VACUUM
TO ROBOT
TO PICK-UP

620 — SHIFT ELAPSED
TIME AND STATUS
TO ROBOT
GRIP POSITION

623 — WAIT FOR INDEX
DIAL READY
SIGNAL

625 — MOVE ROBOT TO
DELIVERY POSITION

629 — REMOVE VACUUM
DELIVER PACKAGE
ARRAY TO DIAL

631 — SHIFT POSITION
STATUS INFO.
TO DIAL POSITION

633 — RETRACT ROBOT

635 — INDEX PACKAGE
DIAL

GO TO STEP
403, FIG.IOA

FIG.IOF

FROM STEP 710
N

810 — RELEASE STACK

GO TO STEP
403, FIG.IOA

618 — COMMUNICATE
INDEX TABLE
PLACE POSITION

FIG.IOE

FROM STEP 710
Y

711 — CALCULATE BAD
PACKAGE PICK-UP
POSITION

713 — COMMUNICATE BAD
PACKAGE PICK
UP POSITION

715 — START AND MOVE
ROBOT TO
BUFFER AREA

a16 — WAIT FOR
ROBOT
HANDSHAKE

a19 — TURN ON VACUUM
PICK UP BAD
LENS PACKAGE

a21 — COMMUNICATE
SCRAP PACKAGE
POSITION

a25 — START AND MOVE
TO SCRAP
DELIVERY POSITION

REMOVE VACUUM
TO SCRAP
PACKAGE

GO TO STEP 403
FIG.IOA

42

FIG.II